

The Development of a Decision Support System for the Diagnosis of Chronic Idiopathic Facial Pain

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Dedication to my Mother

for her unconditioned support and love

Abstract

The aim of the research was to develop (a) a well structured electronic medical record for a decision support system, and (b) logical algorithms for the diagnosis of Chronic Idiopathic Facial Pain (CIFP) and for educating trainees.

This project started by validating the paper-based Facial Pain Proforma (FPP) with a panel of 3 experts. The FPP received a top grade consensus for history and examination. However, family relationships were considered too intrusive by one pain specialist and one clinical psychologist. A retrospective survey of 93 free hand pain histories taken by pain specialists (31 records), oral and maxillofacial registrars (12 records), senior house officers (31 records), and postgraduate students (19 records) were compared to the FPP. This revealed illegible data with many omissions. Medically trained surgeons produced good medical and examination data but overlooked important pain related and psychosocial data. Postgraduate students were often patient-led.

A computerised FPP was developed as an electronic medical record - the Electronic Eastman Pain Proforma (EEPP) - using relational database software (Microsoft Access 97). The EEPP was validated for acceptability by clinicians and patients and compared to the free hand history (FH), and the FPP, (119 patients including 40 FH, 46 FPP, and 33 EEPP). Use of the EEPP did not diminish doctor-patient relationship. EEPP's history taking took 22 minutes compared to FPP (18 minutes) and FH (13 minutes). The average rating for EEPP was 2.8 out of 4. The design interface was rated as good. The clinicians were supportive for the concept of an electronic medical record.

"Hand-crafted decision trees" were constructed by using expert knowledge and transcribed into "Diagnostic Rules". Machine learning technique were also used to induce comparable diagnostic trees from patient data (n = 280). 5-fold cross validation of two induced decision trees showed diagnostic accuracy of 88% and 86%, with reasonable comprehensibility and high discriminative performance.

The hand-crafted decision trees were validated using the same data. The resulting accuracy was 85% but comprehensibility was better than that of the induced decision trees.

This work strongly supports the development and use of electronic medical records and a diagnostic decision tree system for clinical use.

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Glossary of Acronyms

AFP	Atypical facial pain
AO	Atypical odontalgia
BMS	Burning mouth syndrome
BNF	British National Formulary
CART	Classification And Regression Tree
CDSS	Clinical Decision Support System
CIFP	Chronic Idiopathic Facial Pain
CN	Cranial nerve
CNS	Cranial nervous system
CSQ	Consultant Satisfaction Questionnaire
CT	Computer Tomography
DDWR	Disc displacement with reduction
DICOM	Digital Imaging and COmmunications in Medicine
DNIC	diffuse noxious inhibitory controls
DSS	Decision Support System
EEPP	Electronic Eastman Pain Proforma
EHR	Electronic Health Record
EPR	Electronic Patient Records
EPT	Electrical Pulp Test
FAM	Facial arthromyalgia
FPP	Facial Pain Proforma
HISS	Hospital Information Support System
HL7	Health Level 7
IASP	International Association for Study of Pain
KDD	Knowledge Discovery in Database
MH	Malcolm Harris
MRI	Magnetic Resonance Imaging
MS	Multiple sclerosis
MSC	Post graduate oral and maxillofacial surgery students
NHS	National Health Service
NSAID	Non-steroidal anti-inflammatory drug
OA	Osteoarthritis
OD	Oral dysaesthesia
OMFS	Oral maxillofacial registrars
PACS	Picture Archiving and Communications System
PC	Premthip Chalidapongse
POMR	Problem-Orientated Medical Record
PP	Pulpitis
PSP	Pain specialists
QUIS	The modified Questionnaire for User Interface Satisfaction
RDC/TMD	Research diagnostic criteria for temporomandibular disorders
RDMS	Relational Database Management System
SG	Substantial gelatinosa
SHO	Senior house officers
SNOMED	Systematised Nomenclature of Medicine
SOAP	Subjective, objective, assessment, plan
SP	Substance P
SQL	Structure Query Language

TA	Temporal arteritis
TENS	Transcutaneous electrical nerve stimulation
TMD	Temporomandibular disorders
TMJ	Temporomandibular joint
TN	Trigeminal neuralgia
UMLS	Unified Medical Language System
VBA	Visual Basic for Application
XML	Extensible Markup Language

CHAPTER 1

INTRODUCTION

1.1. Aims and Motivation

The aim of this research programme was to explore the potential for developing a computerised decision support system for chronic idiopathic facial pain (CIFP) diagnosis. The motivation for this is twofold. Firstly, there is a difficulty in the diagnosis of chronic idiopathic facial pain for several reasons; (1) there are no specific positive identifiable findings which can be detected from clinical examination, radiographic, and laboratory investigation, (2) the diagnosis of chronic idiopathic facial pain needs a multidimensional approach requiring extensive history taking from different perspectives such as clinical, personal, family, and psychosocial aspect and this takes skill and time, (3) the complexity of the history of the pain and clinical features which overlap with different pain conditions is also one of the difficulties in differential diagnosis. Consequently, patients may receive unnecessary investigations, unnecessary and invasive treatment, and delay in appropriate treatment. Secondly, there are opportunities for deploying computing technology in the field of orofacial pain. This technology would be applied to develop a well structured computerised history-taking support or a computerised medical-dental record which can be used as a clinical-data collecting module supporting the decision support system. Furthermore, logical algorithms for the diagnosis of CIFP can be developed as a guideline in clinical practice and as an educator for the learner. The differential diagnosis would also be provided by the decision support system. This decision support system for CIFP can contribute in a number of ways:

- by ensuring that a complete and accurate clinical history is undertaken;
- by providing rapid access and analysis to the electronic record of all patient histories and subsequent treatment efficacy;

- by providing decision support for diagnosis by less experienced clinicians.

With respect to the complete clinical history, a paper-based pain history proforma has been developed and transferred to a computer-based format. This form was designed for taking the history from pain patients who have a specific set of characteristic symptoms and signs. The potential benefits include a standardised and complete patient history. Decision support in the form of a differential diagnosis can be added to the electronic proforma. If this assists in a more rapid and accurate diagnosis then the potential benefit for the patient is a reduction in inappropriate interventions and more appropriate treatment. Clinicians in training or in situations where facial pain expertise is limited may also benefit. Even the experienced clinician will benefit by access to a database which can be used for:

- audit;
- the recognition of patterns of referral;
- characteristics patterns of the disease;
- drug efficacy or even drug contraindications;
- the prognosis of treatment.

1.2. Background Overview

1.2.1. General Consideration of Pain

Pain is defined by the International Association for the Study of Pain (IASP) as:

'An unpleasant sensory and emotional experience associated with actual and potential tissue damage, or described in terms of such damage' (Merskey & Bogduk 1994)

Pain is always subjective and therefore patients suffering from pain always have their own personal experience. In general, pain can be divided into two main categories: acute and chronic pain. Acute pain is temporary and often self-limiting, has a specific observable cause and purpose, and generally has minimal persistent psychological reactions. The example of acute pain is such as that experienced after trauma or surgery, is a normal response to tissue damage and typically resolves as the injured tissue heals or soon after. Chronic pain is commonly defined as pain that persists beyond tissue healing time,

arbitrarily defined as 3 months, or pain associated with progressive, non-malignant disease. Many patients with chronic pain suffer from clinical syndromes for which there is no evident tissue damage, no confirmatory laboratory tests and which is currently diagnosed on the basis of clinical criteria alone. These common chronic pain syndromes include: chronic low back pain, chronic headache, fibromyalgia, neuropathic pain, and phantom limb pain. Knowledge about the underlying pathophysiology of many of these disorders is limited. The effect of chronic pain on the patient tends to be more intense than that of acute pain. It often affects the patient's mood, personality, and social relationships. Pain patients typically experience concomitant depression, sleep disturbance, fatigue, and decreased overall physical functioning. In contrast to acute pain, chronic pain involves psychological and behavioural mechanisms in addition to physiological mechanisms.

This complex and subjective character of pain can be well explained by Loeser's conceptualisation of the phenomenon of pain (Loeser 2001). This model has proven to be a useful adjunct in the understanding of the components of pain. In this model, the phenomenon of human pain can be characterised by four components: nociception, pain perception, suffering, and pain behaviour (Figure1-1).

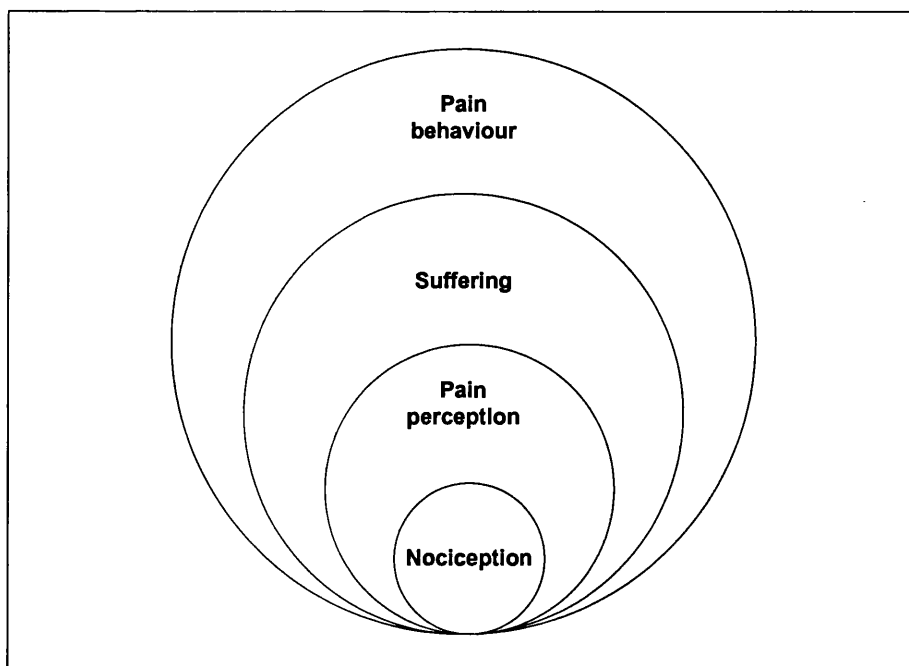


Figure 1-1: Loeser's conceptualisation of the phenomenon of pain (Loeser 2001) [re-drawn].

The model emphasises that nociception, pain perception, and suffering are personal, private, internal events that cannot be measured directly by another human being. Their existence can only be inferred by the assessment of pain behaviour.

Nociception, which refers to anatomical and physiological background, is a sensory process that involves receptor activation (transduction), relay of information from the peripheral to the central nervous system (transmission) by A-delta and C fibers in the peripheral nerves. Pain is the perception of the nociceptive signaling by neural mechanisms in the spinal cord or brainstem and higher centres. Pain can be modified by the descending and ascending modulation of the neural pathway from the higher centres of the brain. Thus, nociception is not synonymous with pain; this process may be necessary for pain to occur, but it is not sufficient to account for pain as a clinical presentation. Nociception is a pathophysiological phenomenon, whereas pain is a perceptual one that involves the central nervous system. As venepuncture may induce a report of pain in one patient, but be inconsequential to another, barrage of nociceptive stimuli may be perceived and reported as pain by one patient, but not necessarily by another. Such variability in individual perception of pain is common. Physiological differences that affect threshold for nociception do not seem to be sufficient to account for the variation observed in patients' responses to the same stimuli. It has been consistently shown that various cognitive, behavioural, and affective factors will influence the perception of pain.

Once pain is perceived by a person, the experience extends simultaneously in two directions. First is the subjective experience of suffering and the second is an externally displayed expression of pain (pain behaviour). Suffering is a negative affective response generated in the forebrain by pain or by a wide variety of emotional states such as isolation, depression, fear, and anxiety (Loeser 2001). Cassell (1982) indicated that suffering reflects a perceived threat to the physical or psychological integrity of the individual. Pain behaviour is the reaction of a person's response to pain and such behaviour is overt expressions that communicate pain and distress to others. Initially, pain behaviour may result from reflex aversive experience and may serve to protect a person from exacerbating tissue damage. Such behaviour includes simple verbal or motor behaviour that are almost automatic, such as moaning, limping and grimacing,

or they can be higher order behavioural patterns such as taking medication or seeking medical help. Occasionally patients acquire and maintain pain behaviour because of environmental contingencies that provide reinforcement for such behaviours. For example, if pain leads to limping and limping elicits attention from family members, a person may adopt a contingency pattern of limping to gain positive reinforcement of his or her experience of pain.

Pain is a common problem affecting the population world wide. According to a 1998 WHO survey of nearly 26,000 primary-care patients in 5 continents, 22% of those surveyed reported that sometime over the past year they had suffered persistent pain (Gureje et al. 1998). Chronic pain complaints are also common in economically developed countries. Jacobson (2001) indicated in his review of the literature that pain is the second most common complaint in the clinician's practice in North America. Also it is the most frequent cause of suffering and disability that seriously impairs quality of life.

Previous epidemiological studies of chronic pain have been completed in the United Kingdom based on patients attending pain clinics. In fact, these patients represent only one sector of the population with chronic pain who seek treatment and are unlikely to be representative of the general population. A survey by Elliott et al. (1999) revealed that 46.5% of a community population in the United Kingdom suffered from chronic pain of which the majority reported back pain and arthritis. A population survey in the United States by Lipton (1993) showed that 1.4% of people in United States of America have had chronic facial pain excluding dental, burning mouth, and TMJ pain in the previous six months. Recently, the study of Aggarwal et al. (2003) by postal survey from the population in the South-East Cheshire indicated that the prevalence of orofacial (including dental, burning mouth, and TMJ pain) pain was 26%.

1.2.2. General Consideration of Chronic Idiopathic Facial Pain (CIFP)

The National Institute of Health (NIH) 1996 states that Chronic Idiopathic Facial Pain (CIFP) is a collection of conditions affecting the temporomandibular joint and/or muscles of mastication as well as the face, mouth and teeth (Anonymous 1997). The diagnosis of atypical facial/atypical odontalgia as written in IASP

(Merskey & Bogduk 1994) is usually made on the basis of exclusion. In fact, like other pains the clinical characteristics are very recognisable and may be readily used as the basis of inclusion criteria. Nevertheless, the criteria for a specific diagnosis of CIFP and the guidelines for its diagnosis and management are to some clinicians' obscure, despite being the most common cause of facial pain after dental pain. There are 4 clinical presentations namely facial arthromyalgia (temporomandibular dysfunction syndrome or temporomandibular joint disorder or myofascial pain dysfunction syndrome), atypical facial pain (atypical facial neuralgia), atypical odontalgia and oral dysaesthesia (burning mouth syndrome). Each is considered to be individual conditions, but they often coexist or occur sequentially in the same patient. The causal mechanism is unknown, and they may be based on the same mechanism because of the overlapping clinical presentation. Furthermore, they are associated with other kinds of chronic pain such as headache, neck pain, back pain, fibromyalgia, chronic fatigue syndrome, irritable bowel syndrome, pelvic pain (often diagnosed as endometriosis) and pruritus (Feinmann & Harris 1984a), (Aaron & Buchwald 2001). There is also an association with post traumatic stress disorder and whiplash injury (Aghabeigi, Feinmann, & Harris 1992). The patient presents typically with a long history of pain and inappropriate treatment which does not correspond to the identifiable findings in the case of atypical facial pain, atypical odontalgia and oral dysaesthesia.

CIFP should be distinguished from dental pain such as that caused by pulpitis with and without a periapical lesion, periodontitis, cracked teeth, sinusitis, migraine, facial migrainous neuralgia, tension headache, chronic osteomyelitis, osteoarthritis, trigeminal neuralgia, and rarely bone pain from systemic diseases such as sickle cell anaemia. Unfortunately, at the present, there is no objective confirmatory test for CIFP. The diagnosis depends on the history of the pain and other perspectives of patient history such as personal, family, social, and psychological. Thus, a thorough complex history is crucial for the diagnosis of CIFP.

The history should reveal the full range and timing of the symptoms, other manifestation of pain, emotional problems, social and family problems, personal health belief, all of which give a clue to performing a focused physical examination. Taking the pain history can be difficult for two reasons; the

complexity of the history (particularly long-standing pain) and communication with the patients. Patients with CIFP often have a long pain history (as is the nature of chronic pain), a long history of investigation of a possible physical abnormality, and many previous interventions by patients themselves or by clinicians. Chronic pain patients often have a degree of anxiety or a depressed mood (Ohrbach & Dworkin 1998). They are very sensitive, occasionally agitated and sometimes difficult to communicate with. Communication with patients may not succeed when the patient and clinician have different languages, experiences, expectations, and frames of reference. Some patients present with a predetermined diagnosis from a colleague, material reading or the internet and are determined to “sell” this to the clinician and resist a diagnosis acquired from first principles. As a clinical symptom, pain is an experience that cannot be shared. It is wholly personal, belonging to the patient alone and empathy is required for full appreciation of the condition. Different individuals with identical noxious stimulation feel pain in different ways and react with different levels of suffering. It is impossible for one person to sense exactly what another feels. Moreover, pain is not only a clinical sensory experience, but it is also something that adversely affects quality of life. The language of pain expression can be transmitted both verbally and non-verbally through the manner, personality and the behaviour of the patient. Clinicians need good listening skills and the ability to understand the pain language that the patient uses during the history taking. In addition, good observational skill is needed to detect the non-verbal language or body language which is usually subconsciously expressed. Thus, much skill is required in pain history taking and the history taker must keep both ears and eyes receptive to these two equally important and complementary communication channels.

The dominant model of disease is based on a biomedical model (Bowling 1997). This assumes that disease is generated by specific aetiological agents which lead to changes in the body's structure and function. The medical view of the body is based on the Cartesian philosophy of the body as a machine. Hence, if a part malfunctions it can be repaired or replaced: the disease is treated, but not always the illness, which is the subjective experience of dysfunction. It sees mind and body as functioning independently, and while disease may lead to psychological disturbances, it does not have psychological

causes. The model is based on the assumption of scientific rationality, with the emphasis on objective, numerical measurement and physical and chemical data. With the biomedical model, health is seen in terms of the absence of disease. Although, this model may be appropriate for some somatic pains, it certainly does not apply to all pains.

The holistic approach employs a biopsychosocial model, which is more adaptable to both diagnosis and treatment than the biomedical model. This model suggests that the person is a complex unit of body and mind (or soma and psyche) and that one cannot separate the mind from the body. It directly influences how the clinician integrates the relative impact of coexisting somatic and psychological factors. In the biomedical model, the causes are categorised as somatic or psychological and when the somatic are excluded, the psychological are to be claimed. The biopsychological model instead accepts that biological, psychological, behavioural and social factors are all present and it is their interaction that affects the individual and the disorder. Thus, the biopsychological model contributes to a coherent understanding of the individual's disease and illness, rather than looking for a somatic or psychological cause.

1.2.3. Pain History Taking

With the biopsychological model, history taking is used not just to understand the disorder but also the patient, to learn why the patient is ill, and to learn how the patient responds to illness. Because medical training usually emphasises the biomedical model, if the identifiable cause can not be found, the clinicians are frustrated and tend to invoke psychological causes; which translates in the patient's mind to an imagined problem.

The challenge of CIPF is the absence of a gold standard in education and training. The alternative approach is to use a process of searching for the identifying symptom clusters and previous history of treatment response as there is no specific biological marker to confirm the diagnosis but the traditional biomedical model, which contains an implicit linear casual relationship between organic change and symptom formation, is not appropriate for explaining CIPF.

The biopsychosocial model is more adaptable in both diagnosis and treatment than the biomedical model.

As stated a clinical history is complicated and rich in information. There are a number of problems that can occur. The patient's symptom reporting may not be reliable. The clinician may not collect all necessary information in a reliable manner, and reliably integrate the collected data in the differential diagnosis. Therefore, a well-structured pain history taking form could be developed to collect the required information.

There are 3 methods for obtaining a history: structured, semi-structured, and open. The structured method is the most reliable and its use also improves the reliability of diagnostic assignment. A structured interview is organised according to a decision-tree and, as such, requires a highly developed taxonomic system with clear-cut criteria that differentiate one disorder from another. Every question should be specifically targeted to collect essential pain related data. Although excellent for research, this method tends to be restrictive in practice i.e. determined by the questionnaire by limiting the information that is obtained, and it is tedious to use.

The open method, familiar to all clinicians is characterised by having no structure and, as such, has a number of problems e.g. inadvertently omitted information, many tangential questions and inadequate responses, premature diagnoses that result in omissions in the history, and generally low reliability in outcome.

The semi-structured method achieves a balance between structured and open interviews. Content regions and areas within regions are all predetermined, but the interviewer has the flexibility to move between areas and regions according to the flow of the interview. This approach minimises the problems of the other two while remaining quite efficient. Its reliability lies between that of the other two methods; the same information may not always be acquired by two interviewers. Diagnosis is also not as reliable, in that more clinical judgement is required. The semi-structured format is recommended because of its efficiency and relative completeness.

There are substantial studies to develop the questionnaires for history taking for facial pain patients, particularly for the differential diagnosis of temporomandibular disorder or facial arthromyalgia (Heir 1993), (Hapak et al. 1994), (Bertoft 1996). The questionnaires mostly are semi-structured in design and provide some benefits in diagnosis. CIFP includes facial arthromyalgia, atypical facial pain, atypical odontalgia, and oral dysaesthesia. However, a consensus of symptoms, signs, and mechanisms of this disorder has not been generally accepted. Criteria for the diagnosis of facial pain, especially facial arthromyalgia (temporomandibular disorders) have been produced, despite the current lack of standardised and validated diagnostic criteria. Mathematical techniques have also been used to support clinical decision-making including Bayesian analysis, the receiver-operator-characteristics (ROC) curve, and decision tree analysis. They may be used to verify the diagnosis in difficult cases but are not appropriate in the clinical setting because they are time consuming.

1.2.4. Clinical Decision Support System (CDSS)

A Clinical Decision Support System (CDSS) is defined by Shortliffe as:

'Any computer program that deals with clinical data or medical knowledge and which performs one or more of the following tasks: serving as a tool for information management; helping health-care workers to focus attention; or giving advice in the form of a patient-specific consultation'. (Shortliffe 1987)

CDSSs have been developed since the end of the 1950s. Until the beginning of the 1970s, a variety of methods and techniques were developed to simulate medical diagnostic reasoning using computers. The significant revolution came in the middle of the 1970s, with the implementation of major medical diagnostic systems such as MYCIN and INTERNIST-1 which were the foundations for many current systems.

Many CDSSs focus on diagnosis. Research in this field is important for many reasons: most of the developed programs are directed at practical applications; they help in the formalisation of medical knowledge; and, they can help in the understanding of human problem solving. Decision support systems for diagnosis generally have three main components, i.e. medical knowledge, patient database or data collection module, and an inference engine. The

medical knowledge contains a store of medical information which is extracted from experts or from publications such as journals and textbooks. The database or collection module is used to collect specific information regarding the signs and symptoms of an individual patient. The inference engine links the patient specific data and generic medical knowledge to simulate the diagnostic reasoning of a clinician. Inference engines for medical decision support system use a variety of techniques based on numerical algorithms, statistics, heuristic rules. Others implicit forms of medical knowledge may be implemented in neural networks (a computerised algorithm for inducing some form of knowledge – e.g. outcome or diagnosis from appropriate patient data set) and other non-symbolic formats.

CDSSs for diagnosis have been developed in dentistry since 1973 (Leonard et al. 1973). There are a considerable number of decision support systems used in dental emergencies, orofacial pain, oral medicine, oral radiology, orthodontics, pulpal diagnosis, and removable prosthodontics. Relatively few evaluations of the efficacy of CDSSs have been carried out. One of the most well known helped to improve the accuracy of diagnosis is in the acute abdominal pain field (de Dombal, Leaper, & Horrocks 1974). In fact, the use of decision support system in diagnosis with systematic feedback has improved the quality of diagnosis and can substantially reduce the rate of serious mistakes in treatment (Adams et al. 1986).

In 1997, a postal survey of computer use in dental practices was carried out in the United Kingdom (Monckton 1997). The response rate of the study was 64%. The proportion of responses where there were computing facilities at the practice was 59 %. This is a dramatic increase from the 22% of practices in a similar survey in 1991. Most of the practices found their computer useful for storing patient details and one third of them use the computer for patient clinical record and charting. The use of computers for a decision making in general dental practice has not been reported. However, nearly one third used it for computer assisted learning and connect to the internet which might imply their requiring supporting information to make a clinical decision.

As was mentioned previously, the diagnosis of CIFP is problematic. Common consequences of this are unnecessary investigations and invasive treatment

leading to medico-legal issues. Decision support systems for the diagnosis of CFP have not been developed. However, there are systems for the diagnosis of facial pain and headache. The first CDSS for the diagnosis of facial pain was described by Leonard et al. in 1973 (Leonard, Robert, Fast, & Mahan 1973). The system used algorithmic reasoning based on a weighted linear pattern recognition technique. The system was capable of some self-training by automatically analysing data from clinical cases to re-assign the weight parameters used in the inference mechanism. Matsumura (1986) developed RHINOS, a system used to diagnose headache and facial pain. The system has four types of rule, acting as a forward link from manifestations to diseases. It also has disease concepts as a backward link from diseases to manifestations. With this knowledge, RHINOS makes a differential diagnosis, and supports the diagnosis of complicated cases of two or more coincident diseases.

1.3. Organisation of the Thesis

The main body of the thesis is organised as follows:

Chapter 2 aims to familiarise the reader with the domain of the investigation. This chapter gives the review chronic idiopathic facial pain including terminology, classification, psychological aspect, clinical presentation, and treatment modality.

Chapter 3 is concerned with the Eastman Pain questionnaire for history taking known as the Facial Pain Proforma (FPP). Two aspects were explored: (1) the content of the FPP was validated by 2 pain specialists and a clinical psychologist, (2) a retrospective study of 93 free hand pain histories was carried out to see their completeness as compared with the FPP. The histories were completed by 5 pain specialists, 9 oral and maxillofacial registrars, 7 senior house officers, and 4 postgraduate oral and maxillofacial students to provide a simple qualitative overview.

Chapter 4 contains a review of medical records in general and electronic medical records, in particular. The Eastman Electronic Pain Proforma (EEPP), is an electronic medical record, and is the computerised version of the FPP questionnaire. The system design and construction of the EEPP including the database model and interfaces are described. A clinical study to explore the

acceptability of the EEPP to clinicians and patients for pain history taking in the consulting room was carried out.

Chapter 5 focuses on Clinical Decision Support Systems (CDSSs) for diagnosis. The definition, the background of a clinician's diagnostic reasoning, a literature review, the basic structure of CDSS, the method of knowledge acquisition, and knowledge representation are explained. A CDSS has essentially 3 components, which in our system were: (1) the knowledge base – diagnostic decision tree designed by the author (P.C.) based on knowledge acquired from a pain expert (M.H.), (2) the computer database and its interface, (3) the inference engine which is a specifically designed programme which links and evaluates the database content to the knowledge decision tree. Decision trees for the diagnosis of chronic idiopathic facial pain acquired from an expert namely “the hand-crafted decision trees” are presented and discussed in the last part of this chapter. “Diagnostic rules” transcribed from the hand-crafted decision trees are documented in Appendix B.

Chapter 6 is concerned with an alternative means to generate a decision tree for the diagnosis of chronic idiopathic facial pain. We introduce a new discipline named “Knowledge Discovery in Database” (KDD) or “Data Mining” which employs “machine learning” techniques to induce a decision tree for the diagnosis of chronic idiopathic facial pain from a patient data set. The definition of machine learning, its task, and one of its techniques namely the decision tree learning algorithm are explained. The detail of how the diagnostic decision tree is constructed using this technique is documented in Appendix C.1. The resulting induced diagnostic decision trees are validated, illustrated, and discussed. Four induced diagnostic decision trees which were highly discriminative are documented in Appendix C.7.

Chapter 7 validated the diagnostic knowledge acquired from the expert or his “hand-crafted decision trees”. Also the diagnostic pathway was tested to find errors, inconsistencies, and incompleteness.

Chapter 8 is the final chapter which provides a summary and conclusions of this research and discusses directions for future work.

CHAPTER 2

CHRONIC IDIOPATHIC FACIAL PAIN (CIFP)

2.1. Introduction

The face and mouth are sites where some of the most common pains occur in the body. These range from orofacial pains manifest as an acute or transient condition, such as pulpal pain, to more chronic conditions such as temporomandibular joint pain that may persist for months or years. Chronic or persistent pain is defined as pain that extends beyond the period of healing, in the absence of pathology, whereas acute pain is defined as pain of relatively short duration elicited by injury of body tissues and activation of nociceptive transducers at the site of local tissue damage (Jacobson & Mariano 2001). Chronic or persistent pain is more problematic than acute pain. The cause of pain often remains poorly understood. It is associated with severe physical, emotional, or social stress to the patient as an individual, and family members. Moreover, despite advances in medical technology and treatment of disease, the treatment of chronic pain remains problematic for the clinician.

This chapter is to review the literature, concepts and controversies of the aetiology of chronic idiopathic facial pain. The final part of the chapter covers the clinical presentation of chronic idiopathic facial pain and the treatment modalities of these conditions.

2.2. Chronic Idiopathic Facial pain (CIFP)

This section focuses on the chronic idiopathic facial pain by beginning at the terminology, classification, and controversies aspects. Then, a psychological aspect is given since it plays an important role in chronic pain including chronic idiopathic facial pain. Clinical feature, diagnosis, and treatment modality are distinguished in an attempt to give the clinical pictures of all conditions in

chronic idiopathic facial pain. This review did not intend to be a systematic review.

2.2.1. Terminology and Classification

Chronic idiopathic facial pain (CIFP) is the most common cause of facial pain after dental pain. It is defined as a persistent pain, located in the teeth, oral cavity, perioral cavity, or the face. CIFP embraces 4 main disorders i.e. facial arthromyalgia (Temporomandibular disorders or TMD), atypical facial pain, atypical odontalgia and oral dysaesthesia. They are often considered to be individual conditions, but they may coexist or occur sequentially in the same patient. They display common clinical characteristics, one being that the pain does not appear to follow a neuronal pathway. Chronicity and continuity of symptoms are important characteristics that patients with these complaints share. In addition, there is no identifiable investigation that can be related to these complaints. Furthermore there is no known aetiology. For these reasons, a unified concept of idiopathic orofacial pain has been suggested (Harris 1996). The explanation for this unifying concept is that emotional strain, together with local physical stress in a biochemically and psychologically vulnerable subject, promotes the inappropriate release of neuropeptides in the target tissues such as the joint capsule, cervicofacial muscles, periodontal membrane or dental pulp. It is believed that grouping of these conditions into a single category provides advantages in that we can investigate their common aetiologies and pathologic mechanisms. CIFP is often associated with other chronic pain such as headache, neck pain, back pain, pruritus, abdominal pain (irritable bowel syndrome), and pelvic pain (Feinmann & Harris 1984a). In addition, recent evidence has revealed that chronic fatigue syndrome (myalgic encephalomyelitis), fibromyalgia, and facial arthromyalgia (TMD) share common symptoms, including generalised pain, sleep and concentration difficulties, bowel complaints, and headache (Aaron, Burke, & Buchwald 2000). Moreover, the dysregulation on several levels of the hypothalamic-pituitary-adrenal axis, together with genetic vulnerability, previous stress experience, coping and personality styles, have been proposed to explain the pathophysiology of chronic pain and other stress-related bodily disorders such as chronic fatigue syndrome, post traumatic stress disorder, fibromyalgia, rheumatoid arthritis, and asthma (Heim, Ehler, & Hellhammer 2000). Recently, the priority given to

anatomic criteria in pain classification systems has been questioned because these may reclassify pain entities that share common clinical features and/or mechanisms purely on an organ or tissue basis (Woolf et al. 1998). However, it is still useful to review the clinical features and mechanisms of these associated types of persistent orofacial pain for purposes of both research and treatment. Furthermore, the concept of a central mechanism(s) is further supported by the fact that peripherally oriented therapies have commonly failed with these patients (Beard & Clayton 1980), (Turk, Zaki, & Rudy 1993), (Dao et al. 1994). Turk and Rudy (1992) proposed multi-axial assessment of patients classification which allows patients to be classified according to the treatment outcomes. Their classification comprises of three groups: dysfunctional, interpersonally distressed and adaptive copers. They suggested that this is independent of diagnosis. This classification was validated in patients with low back pain, facial arthromyalgia and head pain. The result suggested that treatments was based on these three categories rather than on the aetiology but the evidence is still lacking (Zakrzewska 2002a). It seems logical that these chronic, poorly understood facial pain conditions be grouped together so that common mechanisms can be investigated and better understood. It should be noted that the main goal for using the unified concept is not to propose a definitive system of classification but rather to stimulate reflection of this aspect of orofacial pain taxonomy. Another goal is to facilitate reasoning, which we hope will lead to an improved diagnostic process for these conditions. The term arthromyalgia was suggested to emphasise the similarities with the other idiopathic pain entities such as fibromyalgia, to stress that these similarities may be as meaningful as overlapping subdivisions (Feinmann & Harris 1984a), and to improve both taxonomy and understanding of mechanisms.

2.2.2. Psychological Aspects

It is now generally recognised that psychological factors play an important role in chronic pain. The concept of pain must be understood not just in sensory-discriminative terms (nociceptive terms) but also in psychological terms. According to Loeser's conceptualisation of the phenomenon of pain (Loeser 2001), the phenomena of human pain begins with the perception of nociception, followed by pain appraisal, pain behaviour, and finally social role for illness and suffering as mentioned in the previous chapter. Although physicians recognise

the pain problem, many find the diagnosis and treatment of pain states perplexing and frustrating. In some cases the root of the difficulty is the physician's fundamental understanding of pain. The appropriate approach to understand and assess pain, to diagnose it, and to manage chronic pain is based on a biopsychosocial model as mentioned in Chapter 1. The biopsychosocial considerations are important for patients who present with chronic idiopathic facial pain, because these patients do not present with demonstrable organic changes. With these patients, it is useful for the clinician to determine the patient's perspective, as this may provide clues to possible non-physical aspects of the problem in addition to their physical pain symptoms (Marbach & Lipton 1987).

According to the gate control theory of pain, tissue damage concurrently activates motivational-affective and sensory-discriminative components of pain. Thus, the nature and severity of pain become consequences of affective and cognitive mechanisms as well as sensory afferent events due to tissue damage. To understand pain perception, therefore, needs not only the sensory component, but also a variety of psychological influences including cognitive-evaluative, motivational-affective, behavioural and sociocultural dimensions. The next section will discuss such factors of pain as well as reviewing the associated evidence related to chronic idiopathic facial pain.

2.2.2.1. Cognitive Factors of Pain

Cognition is defined as "the intellectual functions or ways of knowing and thinking including the process of perceiving, imagining, remembering, reasoning, and judging" (Churchill's illustrated medical dictionary. 1989). The cognitive theory has studied the influence of the meaning of pain to patients, and examined the effect of coping styles on pain. Cognitive theory examines intervening variables such as attributions, expectations, beliefs, self-efficacy, personal control, attention, problem solving, coping, self statement, and imagery (Gamsa 1994). The effects of these thought processes on the experience of pain have been investigated in pain studies. Cognitive theory has played an important role in psychological studies in pain research. Its association with behavioural theory has been extensively involved in the treatment of pain patients.

2.2.2.2. Behavioural Factors of Pain

According to the review of Suvinen and Reade (1995), the behavioural model has been applied in the study of pain by Fordyce et al. (1968). The conceptual idea of this behavioural model was based on Mechanic's proposed idea (Mechanic 1962) which indicated that the ways in which given symptoms may be differentially perceived, evaluated, and acted (or not acted) upon by different people. Several factors have been considered to influence illness behaviour such as social class, social role, age, gender, learning, cultural factors, stress, interpersonal factors, and even the type of illness. Pilowsky (1978) introduced the concept of illness behaviour as the persistence of an inappropriate or maladaptive mode of perceiving, evaluating, and acting in relation to one's own state of health. It has been documented that cultural, ethnic, social and family factors have influenced pain experience and expression of pain (Bates, Edward, & Anderson 1993). The classical study by Zborowski (1952) indicates major inter-ethnic differences in Irish, Italian, Jewish, and Old American patients. The data were collected by observation and interview and the result showed that Jewish and Italian patients were more emotional and more expressive about their pain than the other two groups.

2.2.2.3. Motivational-affective Factors

Pain is often associated with affective factors such as anxiety, fear and depression (Craig 1994). It is still not clear whether affective processes should be reviewed as causes or consequences of pain. It is common to find concomitant depression in painful conditions. The causal relationship of depression and pain is as yet unclear, although the evidence suggests that pain is more likely to precede depression (Fishbain et al. 1997). It is estimated that the prevalence of depression among patients with various pain conditions has been between 10-100 % (Romano & Turner 1985) depending on the method of assessment and the population assessed. From the review of Gamsa (1994), there have been many attempts to explain the relationship between emotion and pain including biological, psychodynamic, cognitive, and behavioural models. Biological theories focus on the dysregulation of the responsible neurotransmitters that are thought to mediate neurophysiologic pathway in the regulation of pain and emotion. Psychodynamic theories view the association of

affective factors and pain as an inability to modulate and express intense, unacceptable feelings such as anger or feeling of guilt. Cognitive theories emphasise this as thoughts of helplessness and lack of control, while the behavioural theories emphasis this as the role of severe reduction of activity in chronic pain. There has been much evidence demonstrating the relationship between stress, failure to cope, affective distress, and pain in several studies (Turner, Jensen, & Romano 2000), (Jensen, Turner, & Romano 2001). The model explaining the relationship of the affective dimension of pain based on psychophysiology concept of how the central nervous system mechanisms that process painful or stressful stimuli are disrupted has been mentioned in the literature (Clauw & Chrousos 1997), (Chapman 2001), (Aaron & Buchwald 2001). This hypothesis demonstrated that both genetic and environmental triggers may interact to cause dysfunction of the central nervous system including hypothalamic-pituitary axis, nociceptive processing by the peripheral and central pain pathways, and autonomic nervous system. However, the evidence supporting the relationships between pain, anxiety, and tension with many musculoskeletal disorders is still inconsistent (Flor & Turk 1989). The authors examined studies of tension headaches, chronic low back pain, temporomandibular disorders (facial arthromyalgia), and migraine headaches. They found little evidence for elevated baseline levels on physiological measures in patients with these disorders. However, some evidence for a relationship between psychophysiological response to stressful situations and specific symptoms of patients with head, back or temporomandibular pain has been found. Their review failed to reveal consistent support for a causal relationship between abnormal physiological patterns and pain. The other study using positron emission tomography (PET) to measure cerebral blood flow revealed neuronal activity in the anterior cingulate cortex and the prefrontal cortex in the atypical facial pain group (Derbyshire et al. 1994). These findings show the importance of the anterior cingulate cortex which plays role in the affective dimension of pain and the reciprocal (possibly inhibitory) connections with the prefrontal cortex in the processing of pain in patients with this disorder.

2.2.3. Clinical Presentation and Diagnosis

The definition, terminology, clinical features, epidemiology, demography, and hypothesized mechanisms will be discussed in the next paragraph.

2.2.3.1. Atypical Facial Pain (AFP)

(1) Definition and Terminology

Atypical facial pain is usually described as a continuous dull ache, with intermittent excruciating throbbing episodes that are localised to a non-muscular site such as the alveolar bone or over the maxillary antrum without identifiable cause (Harris & Feinmann 1990). This term was first described by Frazier and Russell (cited by (Harris & Feinmann 1990)) in 1924. There is no precise definition for atypical facial pain because the term was coined to cover all unexplained cases of pain. There are 2 different concepts regarding to the use of this term. The first is that described by the International Association Study of the Pain (IASP) (Merskey & Bogduk 1994) and International Headache Society (IHS) (Anonymous 1988), which suggested that the term should be abandoned in favour of '*other and unspecified pain in the jaws*' or by '*facial pain not fulfilling other criteria*'. These terms would regroup all the intermediate clinical situations that do not fall into one of the well-defined categories. The term is thus employed as a '*wastebasket*' definition, which can only be applied by elimination. The other subgroups that had not been identified at the time, such as TMJ disorders or cluster headache, could also be included in the group. The second diagnostic concept of atypical facial pain is of that aimed to describe it as a relatively homogeneous subgroup of facial pain. Diagnosis thus becomes a positive procedure rather than one accomplished by elimination.

(2) Epidemiology

There is no epidemiological data for AFP. One difficulty has been said that there is no clearly defined set of diagnosis criteria. A very high preponderance of female sufferers has been indicated from previous studies (Gerke, Richards, & Goss 1992), (Feinmann & Harris 1984a). The average age affected is around 40-46 years with range 30-55 years (Harrison 2002a).

(3) Aetiology

The pain mechanism appears to be vascular and the patient often suffers from other pains with a muscular or vascular quality which may include neck, shoulder, and back pain, and also have a history of peptic ulceration, irritable bowel, dysmenorrhoea, menorrhagia and pruritus (Feinmann & Harris 1984a). It

has been argued that AFP may be a form of deafferentation pain or represents a heterogeneous group of idiopathic pains including post-viral syndrome. For these reasons the term 'atypical facial pain' has been declared unfashionable by the IASP.

(4) Clinical presentation

The pain may be bilateral with a wide extrafacial distribution and is not provoked by jaw movements and rarely relieved by analgesics. Occasionally there is a strong resemblance to facial migrainous neuralgia with a sensation of nasal stuffiness or obstruction, and the pain waking the patient in the early hours of the morning. Bouts of pain may last for hours or days and the patient may have a history of intermittent pain over a period of many years. A common feature is that the pain may be provoked or potentiated by trauma or dental treatment. In the older edentulous case, the patient cannot wear one or both dentures despite bone smoothing procedures. Apart from occasional marked hyperaemia of the oral mucosa or slight oedema of the face, there are no clinical signs. Feinmann and Harris (1984) showed that AFP patients did not differ from facial arthromyalgia (FAM) patients in their psychiatric morbidity or sociodemographic characteristics. Harris and Feinmann (1990) indicated that the symptom complexes are not mutually exclusive and many occur sequentially or simultaneously in the same patient. There are often associated with depression, anxiety, intense stress, or a distressing life event preceding the onset of pain (Feinmann & Harris 1984a).

2.2.3.2. Facial Arthromyalgia (Temporomandibular Disorders)

(1) Definition and terminology

Facial arthromyalgia (FAM) affects the temporomandibular joint (TMJ) and muscles of mastication. This condition represents a group of usually painful and/or dysfunctional characteristics involving the muscles of mastication and the TMJ. Since first proposed by Costen (1934), many descriptive terms for facial arthromyalgia have been used. According to Okeson (1997), the terms proposed include TMJ dysfunction syndrome, TMJ pain-dysfunction syndrome (TMJPDS), Myofascial pain-dysfunction syndrome (MPD), Craniomandibular disorders (CMDs), Temporomandibular pain-dysfunction syndrome, and

Temporomandibular disorders, (TMDs). There is no consensus on the definition of FAM as it is the result of no known pathophysiology. It has become increasingly clear that FAM symptoms are very similar to those of many other types of stress-related disorders such as fibromyalgia, tension headache, and chronic fatigue syndrome. The patient suffers from pain that can not be easily explained by a somatic origin; the pain related to the masticatory muscles and/or TMJ is the main sign. Many recent systems of classification differentiate these conditions into muscle related pain, intracapsular or disc displacement, and degenerative disorders (Dworkin & LeResche 1992), (Truelove et al. 1992). The unified term 'arthromyalgia' was suggested here to avoid misleading from a taxonomic and pathophysiologic point of view. There is no clear evidence to indicate that different mechanisms are acting in each of different subgroups. The term 'dysfunction', such as clicking, locking, and deviation of mouth opening, may be inappropriate given the fact that almost all patients seek treatment because of pain (Dworkin, Huggins, & LeResche 1990). The term 'TMJ' has been discontinued as an overall descriptor because it is inaccurate and misleading, implying a structural aetiology when there is no clear supportive data. Moreover, there are more important factors involved such as psychosomatic factors and behavioural factors.

(2) Epidemiology

There are some difficulties in studying of the epidemiology of FAM. This is because there is no single accepted definition for FAM as a global term and no consensus in the classification of FAM. Recently, diagnostic criteria for temporomandibular disorders have been introduced (Dworkin & LeResche 1992). This is useful in research for enrolment of homogeneous cases. However, their validity needs to be evaluated in a clinical setting. According to the comprehensive review literature of LeResche (1997), the population-based prevalence studies of pain in the temporomandibular region in North America and Europe was approximately 10% of the population over 18 years thus pain in the temporomandibular region appears to be relatively common. It is primarily a condition of young and middle-aged adults, rather than children or the elderly, and is approximately twice as common in women as in men. However, it has been claimed that men are equally affected but many more women seek treatment, emphasising the importance of consulting behaviour (Feinmann &

Ibbetson 1999). The results of studies of TMJ pain among children in Japan and Scandinavia suggest that the prevalence of TMJ pain is relatively uncommon in children aged 7-17 (Nilner 1981), (Ogura et al. 1985), (Nilner & Lassing 1981). It appears that pain reporting may increase somewhat with age in this group. The gender differences in prevalence seen in adults are not apparent in children; rates of pain in the temporomandibular region appear to be similar for girls and boys. The prevalence rate of TMJ sound across studies by Carlsson and LeResche in 1995 revealed that TMJ sounds occurred with wide variability, from 6-50 % (Carlsson & LeResche 1995). However, a joint sound can be detected in a significant proportion of the normal non-patient population indeed approximately 33% of people have a TMJ click without pain or significant dysfunction (Katzberg et al. 1996), (Morrow et al. 1996). This suggests that a TMJ click may be a normal variant rather than a disorder.

(3) Natural history of FAM

The natural history of FAM should be taken into account when studying epidemiology. The understanding of the natural history and some of the physical changes has played an important role in the treatment, management, and assessment of prognosis. Longitudinal studies have shown that there is variant of specificity of the fluctuation in the symptoms of pain among those persons who report pain at any time point (Drangsholt & LeResche 1999). The longest follow-up study by de Leeuw et al. (1995) reported the status of a subset of patients conservatively treated for TMD pain with either reducing or permanent disc displacement. At baseline, 93% of the subjects had pain, and 30 years later, only 5% still reported pain. It is indicated that most people with temporomandibular region pain will be pain free or have reduced pain at later follow-up in minimally treated groups and a small minority, usually less than 20%, have either continued or increased pain.

Masticatory muscle pain varies in location and intensity with time and the majority of cases resolve without intervention (Stohler 1997). Masticatory muscle pain does not appear to progress in severity with age. Present knowledge indicates that, in general, patients with FAM would be expected to improve in time without intervention. The natural course of internal TMJ derangement has been shown to generally develop favourably without

treatment (de Leeuw et al. 1995). The morphology of condyle and its position related to the glenoid fossa seem not to predict the prognosis or be associated with symptoms. Thus, it may be considered a physiological adaptation. Associations between FAM and other disorders such as headache and neck pain are well established.

(4) Aetiology

Costen's hypothesis has been universally recognised and has influenced the concept of Facial arthromyalgia. Costen's concept is that in the absence of molar support, the powerful elevating muscles of the mandible press the condyles upward and backward, causing damage to vessels and nerves, including the chorda tympani (Costen 1934). This concept, or variation of concepts, was endorsed by many clinicians. The belief is that a specific structural preconceived jaw or occlusal relationship is required for proper definitive TMD management. It is now accepted that there is no evidence that malocclusion will give rise to FAM (Harris & Feinmann 1990), (Anonymous 1997), (Marbach & Raphael 1997). The evidence from well-designed controlled clinical trials have not supported that malocclusion could cause facial arthromyalgia (Dao, Lavigne, Charbonneau, Feine, & Lund 1994), (Forssell et al. 1999), (Koh H & Robinson PG. 2003). On the other hand, there is much evidence that stress, diverse life events and vulnerable personality types predispose to the condition (Feinmann & Harris 1984a), (Speculand, Hughes, & Goss 1984), (Rollman & Gillespie 2000).

The neuromuscular physiology concept proposed by Yemm (1985) showed that central neuromuscular influences give rise to muscle hyperactivity, bruxism and joint overloading rather than local reflex disturbances. This suggests that FAM is a combination of a traumatic arthrosis due to bruxism with associated painful dilated capsular and muscular blood vessels.

Laskin (1969) proposed the psychophysiological concept that FAM is caused by an interaction between a physiological predisposition and by psychological and physical stress. The effect on the individual depends on his or her ability to adapt to stress. The term "myofascial pain dysfunction (MPD) syndrome" was

adopted to emphasise that the muscles, not the joint, are the most important component.

In the late 1980s and early 1990s, the knowledge of basic mechanisms of pain and major advances in the neurophysiology and neuropharmacology of pain substantial occurred. The basic mechanisms of different pains such as nociceptive pain, neuropathic pain, and sympathetically maintained pain began to be understood. Later, central nervous system (CNS) plasticity was proposed as causing the pain to persist long after the original injury, and this may explain the mechanism of chronic idiopathic facial pain.

(5) Clinical Presentations

Pain is the most frequent symptom of FAM that caused the patient to seek a clinician. Pain is located in the muscles of mastication, preauricular region, or TMJ on one or both sides. Pain is continuous but can be triggered or exacerbated by movement or function. Sleep disturbance is a common complaint. Remission period is varied. Intensity of pain may vary over time and it is generally mild to severe. Pain is often described as dull aching or sharp during jaw movement. There is no paroxysmal character or neurological signs. Limitation or asymmetry of mandibular movement and noise in the joint described as clicking, popping, crepitus and an association with bruxism are common. However, there is no hard evidence to confirm that bruxism is the cause. There are other symptoms and signs such as tinnitus, sense of fullness in the ear, hearing loss, dizziness and headache. Psychological factors such as depression, somatoform disorder and hypochondriasis are frequently present and may predispose and perpetuate the condition. As stated, there appears to be a strong clinical association with other pain symptom elsewhere in the body such as headache, migraine, neck pain, back pain, irritable bowel syndrome, pruritus, dysfunctional uterine bleeding and dysmenorrhoea.

2.2.3.3. Atypical Odontalgia (AO)

(1) Definition and Terminology

Atypical odontalgia may be defined as pain of dental or alveolar in origin without any discernible cause (Rees & Harris 1979). Atypical odontalgia probably

represents a clinical form of atypical facial pain (Reik 1984). The difference is justified by its location to one tooth or more. The synonym terms for atypical odontalgia include “phantom tooth pain”, “idiopathic periodontalgia”, “neuropathic orofacial pain” and “chronic neuropathic pain”.

(2) Epidemiology

Prevalence in the population-base is unknown. A postal survey questionnaire to patients who received endodontic treatment has revealed a 3-6% incidence of atypical odontalgia (Marbach et al. 1982) and 1:125000 individuals in the USA. (Vickers & Cousins 2000). In the telephone survey to patients who underwent surgical removal of a third molar has indicated a rare incidence of 0-0.38% (Berge 2002). Females constituted 68-100% (Rees & Harris 1979), (Bates & Stewart 1991), (Schnurr & Brooke 1992), (Vickers et al. 1998), with an average age between 40-51 years (Graff-Radford & Solberg 1992), (Bates, Edward, & Anderson 1993), (Vickers, Cousins, Walker, & Chisholm 1998).

(3) Aetiology

The condition has been considered to be a deafferentation neuralgia arising when a dental extraction or pulp extirpation produces either an amputation neuroma or central mechanism change (Marbach 1993). The central change may be explained by Sessle (2000) as a neurogenic plastic change. However, Harris argued that even though repeated root canal therapy and local surgery could produce a deafferent neuralgia, there are many cases without a history of extraction or pulp extirpation, and with pain that migrates across the mid line (Harris & Feinmann 1990). Moreover, AO is not consistently abolished with a dental local analgesic block as would be expected in deafferentation neuralgia. Furthermore, attempts to curette or excise microscopic neuromas have invariably had little effect beyond 1-2 weeks.

(4) Clinical Presentations

According to Harris and Feinmann (1990), the pain is severe and throbbing in character and the teeth are hypersensitive to any stimulus. It is often widespread and bilateral but occasionally may be precisely localised. Marbach (1993) characterised AO as a continuous dull, boring, or aching pain with

occasional spontaneous sharp pain. Intensity is moderate to severe but allows for normal sleep.

2.2.3.4. Oral Dysaesthesia (OD)

(1) Definition and Terminology

The IASP classification of chronic pain use the term “glossodynia and sore mouth” and defines it as “a burning pain in the tongue or other mucous membrane” (Merskey & Bogduk 1994). This definition infers the extent of a symptom of burning pain without the restriction of normal clinical mucosa from any causes. Thus, erosive lichen planus, and geographic tongue, which usually present with obvious clinical sign in the oral mucosa, can be included in this criterion. Some authors used “burning mouth syndrome (BMS)” and defined it as a condition which patients complain of a continuous or intermittent burning sensation in one or more areas of the oral mucosa without a normal clinical signs (Grushka 1987), (Lamey & Lewis 1989), (Bergdahl & Anneroth 1993). However, this definition still places the burning mouth as a symptom of other causes that are classified under the broad headings: local, systemic, and psychological causes (Grushka & Sessle 1991), (Toune & Friction 1992), (Bergdahl & Anneroth 1993). Apart from burning pain, there are other symptoms such as disturbance of taste (dysgeusia), disturbance of salivation, altered taste (Zakrzewska & Hamlyn 1999), paresthesia (Eli et al. 1994), and denture intolerance (Harris & Feinmann 1990). Recently, Woda and Pionchon (1999) suggested the term ‘*Stomatodynia*’ and defined it as pain in the oral mucosa that cannot be attributed to any known structural cause. The authors excluded intraoral pain that could be explained by local or systemic pathology. The other synonyms for oral dysaesthesia have been recognised as glossodynia, glossalgia, glossopyrosis, stomatopyrosis and idiopathic glossodynia.

(2) Epidemiology

The prevalence of oral dysaesthesia varies depending on a definitive criterion of oral dysaesthesia, the selected sample, and the method of study. Most epidemiological studies have been conducted in single selected samples or clinical setting rather than in a population base. The method of study has been performed by cohorts, and few studies include clinical examination to allow

distinction between burning mouth symptoms and the condition of oral dysaesthesia. Locker and Grushka (1987) have studied the prevalence at population level. In a postal survey 4.5% of a random sample of the adults of Toronto had experienced prolonged oral burning. A study in a Finnish population at population base level showed that 7.9% of the population had oral dysaesthesia without any clinical lesion (Tammiala-Salonen, Hiidenkari, & Parvinen 1993). Hakeberg et al. (1997) reported the prevalence of oral dysaesthesia as 4.6% among middle-aged and elderly women. Recently, the study in a Swedish population has shown that the prevalence of oral dysaesthesia without abnormal clinical signs was 3.7% (Bergdahl & Bergdahl 1999) and increased in older age. Basker et al. (1978) reported that 5.1% of adult patients attending dental practices in Birmingham and the West Midlands had an experience of a prolonged burning sensation. Females are affected more than males. The ratio of females to males is 3:1 in Finnish population (Tammiala-Salonen, Hiidenkari, & Parvinen 1993), compared to 4:1 in Swedish population (Bergdahl & Bergdahl 1999). The ratio of females to males in clinical studies is higher than in population studies with rates of 4.2 % in females and 0.8 % in males (Basker, Sturdee, & Davenport 1978). This suggests that females are more likely than males to seek medical assistance. The average age of oral dysaesthesia is 55 years overall with a mean of 51 years for males and 57 years for females (Tammiala-Salonen, Hiidenkari, & Parvinen 1993), whereas, the mean age is 59 years for males for 57 years for females in other population studies (Bergdahl & Bergdahl 1999). Grushka (1987) reported the ratio of female to male is 3:1 and mean age is 50 years.

(3) Clinical Presentations

The clinical controlled study by Grushka extensively described the clinical features of OD (Grushka 1987) which showed that symptoms had gradual onset in more than two thirds and sudden onset in one third of the patients. The predominant feature is the symptom of burning pain. The pain is often reported either begins by mid morning or early afternoon and reaches maximum pain intensity by early evening, or else is constant throughout the day which is similar to other studies (van der Ploeg et al. 1987), (Lamey & Lewis 1989). The most common site is anterior two third of tongue, the anterior hard palate, and the mucosal aspect of lower lip. The symptoms are often bilateral. Oral

dysaesthesia is present over a number of years but there may be remission periods. Although one third of OD patients are able to relate the onset of OD to a previous dental treatment, most patients are unable to recall any precipitating factor. In more than half of the subjects in this study, the burning pain increased by emotional tension (78% of subjects), fatigue (54%) and decreased burning with sleeping (69%), eating meal (58%), cold food (52%), working (52%) and distraction (48%). The character of alleviating by eating meal and cold food has been observed by Harris and Feinmann (1990), and may be used for differential diagnosis from organic burning pain. There are other associated subjective symptoms such as dry mouth, dysgeusia, and altered taste perception. The persistent taste was usually identified as bitter, metallic, salt, or a combination of bitter and metallic (Grushka & Sessle 1991). Current evidence clearly indicates a strong psychological component with OD, usually depression and/or anxiety (van der Ploeg, van der Wal, Eijkman, & van der Waal 1987), (Eli, Kleinhaus, Baht, & Littner 1994). However, no casual relation can be drawn between the relationship of OD and psychological factors.

(4) Aetiology

Psychogenic factors have been proposed to play a pivotal aetiological role (Grushka & Sessle 1991). There are two reasons, firstly the demonstration of emotional disturbance in patients compared to control groups has been reported from studies (van der Ploeg, van der Wal, Eijkman, & van der Waal 1987), (Eli, Kleinhaus, Baht, & Littner 1994). Secondly, the study of tricyclic antidepressants (TCAs) medication on OD, which demonstrated the effectiveness of TCAs in treating OD (Feinmann & Harris 1984b), (Sharav et al. 1987).

Menopause has been thought being a suspect aetiological factor because most OD patients who present for treatment are postmenopausal females (Basker, Sturdee, & Davenport 1978), and the early literature suggested that hormone changes at menopause can cause oral discomfort (Basker, Sturdee, & Davenport 1978), (Wardrop et al. 1989).

Early literatures linked OD and nutritional deficiency such as iron, B12, and folic acid. One study found a significant correlation of OD and deficiency of vitamin

B1, B2, and B6 and replacement therapy has shown high success rate (Lamey et al. 1986). However another study has not found a significant response of this treatment. Many studies have indicated a very low association with nutritional deficiency (Grushka 1987), (Wardrop, Hailes, Burger, & Reade 1989).

Although, residual monomer of acrylic base of dentures has been suggested to be a cause of OD, recent studies have not supported an allergic lesion to dentures as an important cause of OD (Yontchev, Medling, & Hedegard 1986), (Skoglund & Egelrud 1991), (Helton & Storrs 1994).

2.2.4. Treatment Modalities for CIFP

At present, it has been accepted that the standard guidelines for management of CIFP are not available. The National Institutes of Health Technology Assessment Conference on the management of Temporomandibular Disorders recommended that the practitioners and the patient must develop a treatment plan that is evidence-based and patient centered (Anonymous 1997). Traditionally, the treatment to CIFP has varied according to the clinician's conceptual theory of aetiology and individual's discipline. CIFP is regarded as a complex chronic pain problem which required an integrated multidisciplinary approach (Anonymous 1997). No single discipline has all the skills and training necessary to address this multifaceted problem without consultation and participation from other professionals. Each member of multidisciplinary team would contribute his or her specialised knowledge and skills to provide the diagnosis and the most effective management. Due to a lack of clear aetiology, the goal of treatment of CIFP is primarily aimed at pain and/or dysfunction. Moreover, treatment of facial arthromyalgia should be noninvasive and reversible. The treatment modalities of CIFP including reassurance, pharmacological therapy, interocclusal orthosis, physical therapy, behavioural and psychological therapy especially tricyclic antidepressants, and surgical approaches, have been summarised here in the following paragraph. According to the National Institutes of Health Technology Assessment Conference on the management of Temporomandibular disorders, it has indicated that there is no single treatment or combination of procedures was demonstrated to be effective in randomised, controlled clinical trials. Thus, no specific recommendations can

be made for facial arthromyalgia. However, it does reflect a synthesis of extensive clinical information and long experience.

2.2.4.1. Reassurance

Reassurance is essential for every patient. It demands a sympathetic clinician, a simple explanation of the problem, and a carefully explained and justified course of treatment. The clinician must take the time to explain the clinical findings, diagnostic data, treatment options, and prognosis to the patient. The time spent on patient reassurance and education is a significant factor in establishing a high level of rapport and treatment compliance. Harris and Feinmann (1993) has suggested the appropriate assurance for CIFP patients;

'With a psychogenic pain diagnosis, it is vital to emphasis that the pain is real and not imaginary, arising in cramped muscles and dilated blood vessels as a response to stress. With atypical odontalgia, it is helpful to describe it to the patient as being a migraine in the teeth. The patient must also be reassured that this is a common problem and that no serious physical or progressive disorder is present.'

Such information given by a confident clinician accompanied with the thorough history taking and clinical examination can have a powerful effect in reducing a patient's worries, which is an important element in reducing pain and health care seeking. In some pain centres such as the Eastman Dental Institute, a printed handout is given to every patient at the first visit; this is invaluable for communication and reassurance. Several studies have shown that many patients evaluate their symptoms as reduced after such counselling/reassurance, although clinical examination reveals remaining signs of dysfunction.

Supportive patient education has also been recommended by the National Institutes of Health Technology Assessment Conference on the management of Temporomandibular Disorders. Patients should be educated in the aspects of what is known about facial arthromyalgia and most of these problems follow a benign course. Patient education may include education directly to eliminate parafunctional habits (clenching, grinding), exercise, stress management, and dietary modification. For facial arthromyalgia, it is critical to establish realistic expectations regarding the natural course of this condition, which present as periodic episodes of acute pain and dysfunction. It is important that the patient

understands this natural course of facial arthromyalgia. The clinician and patient must work together to establish strategies of management with realistic expectations rather than the clinician offer a specific treatment of the condition to the patients. The patient's acceptance of the management concept is a critical step in increasing patient compliance and coping. In addition, it is ill-advised to assure the patient that this condition can always be cured, so that she or he will remain pain-free. This false expectation can effect the patient's perception and result in a hostile and unhappy patient later.

2.2.4.2. Pharmacological Therapy

There are few well-conducted, randomised, blind, and controlled clinical trials of medication to treat CIFP. Many current therapies are therefore based on clinical case reports, case series, and poorly designed clinical trials. However, this does not mean that they don't have some therapeutic value. A wide variety of drug classes have been used for chronic orofacial pain disorders including analgesics, antidepressants, and muscle relaxants.

(1) Analgesics

Analgesics embrace non-opioid and opioid analgesics. The non-opioid analgesics comprise a heterogeneous class of drugs including the salicylates (aspirin), para-aminophenol derivatives (acetaminophen), and the NSAIDs (ibuprofen and others). According to Dionne's critical review (Dionne 1997), NSAIDs are ineffective for chronic orofacial pain. This contention is based on the result of a placebo-controlled study by Singer et al (Singer & Dionne 1997). Dionne criticised the evidence that supports the use of NSAIDs which may come from the extrapolation from other chronic inflammation such as arthritis. Aghabeighi et al (1997) has shown the painful TMJ joints contain algogenic leukotrienes and neuropeptides which are not inhibited by NSAIDs. The use of NSAIDs in chronic condition must be weighted against the adverse side effects i.e. gastrointestinal irritation and alteration of kidney blood flow. These result from the suppression of prostaglandins by NSAIDs. NSAIDs usually are recommended in controlling mild to moderate pain of acute episodes of facial arthromyalgia.

(2) Antidepressants

According to the meta-analysis of 39 placebo-controlled clinical trials in non cancer pain by Onghena and van Houdenhove (1992) , there are several interested points. First, 74% of chronic pain patients were better when compared to similar patients who received placebo. Second, the analgesic effect is independent of the antidepressant action or use of antidepressants to induce sedation. Furthermore there was no evidence masked depression. Finally, antidepressants that inhibit reuptake of both serotonin and norepinephrine appear to have a greater analgesic effect.

A recent systematic review of antidepressants by McQuay et al. (1996) provided the positive analgesic effect (>50% pain relief) by using the number need to treat (NNT) as the meta-analytical outcome for analgesic and side effects. The NNT for pain relief for a typical facial pain and central pain were 2.8 and 1.7 respectively. This means one patient in 3 and 2 will report >50% pain relief for atypical facial pain and central pain respectively. In addition, the selective serotonin reuptake inhibitors (SSRI) were less analgesic effective than tricyclic antidepressants.

A meta-analysis by Fishbain (2000) has shown the evidence that antidepressants were effective for psychogenic pain and somatoform associated pain disorders. This evidence also strongly suggested that serotonergic-noradrenergic antidepressants may have a more consistent antinociceptive effect than the serotonergic antidepressants.

Harris et al. (1993) recommended the regime of antidepressants in the treatment of CIFP. This may begin with tricyclic antidepressants (e.g. nortriptyline 10-30 mg given at night), and if it proved to be ineffective, it may change to monoamine oxidase inhibitor (e.g. tranylcypromine 10 mg qds. Before 4 pm.). The medication should be taken for at least 6 months. Regression analysis indicated no differential effect across the classes of antidepressants for pain relief (O'Malley et al. 1999).

(3) Muscle Relaxants

It is believed that some forms of facial arthromyalgia with increased muscle activity will benefit from the effect of reduce skeletal muscle tone of muscle

relaxants (The American Academy of Orofacial Pain 1993). Although it has not been directly studied, the efficacy of this drug in facial arthromyalgia, and findings in other musculoskeletal disorders are suggestive of efficacy for muscle relaxant in the orofacial region.

2.2.4.3. Interocclusal Orthosis (Bite splints)

Interocclusal orthosis treatment is controversial but widely used treatment methods for facial arthromyalgia. A scientific basis for the efficacy of occlusal splint is lacking (Dao, Lavigne, Charbonneau, Feine, & Lund 1994), (Turk, Zaki, & Rudy 1993). However, a systematic review of randomised controlled trials by Forssell et al. (1999) showed that there were methodological shortcomings in study design such as inadequate blinding, small sample sizes, short follow-up times, great diversity of outcome measures and numerous control treatments. The suggestive conclusion is that the use of occlusal splints may be of some benefit in the treatment of facial arthromyalgia. This obviously shows that there is a need for a well-designed study. It is reasonable to consider an oral splint to be an adjunctive treatment. Other actual benefit of splint may be tooth protection from bruxism associated with facial arthromyalgia. The occlusal design which is recommended are flat plane splints (stabilisation splint or Michigan's splint) since this causes no occlusal alteration.

2.2.4.4. Physical Therapy

Physical therapy applications to facial arthromyalgia include thermal therapies, acupuncture, low intensive laser, electrical stimulation ultrasonic and manipulative and exercise. There is little evidence that these methods of management cause long-lasting reductions in signs and symptoms of facial arthromyalgia (Feine, Widmer, & Lund 1997).

2.2.4.5. Biobehavioural and Psychological Therapy

There are patients who have not responded well with these treatments. Such patients often have persistent pain and dysfunction associated with emotional problems, thus, they require biobehavioural and psychological therapy. The term 'biobehavioural' refers to proven, safe methods that emphasis self-management and acquisition of self-control over not only pain symptoms but

also their cognitive attributions or meanings (Dworkin 1997). The collective modalities under biobehavioural include electromyographic biofeedback, relaxation, behaviour modification, cognitive behaviour therapy, education, and hypnosis. These methods, especially cognitive-behavioural therapy, show the potential for producing long-lasting benefits when compared with usual clinical treatment (Dworkin 1997).

2.2.4.6. Surgical Management

Surgical approaches to facial arthromyalgia include arthrocentesis, arthroscopy, and arthrotomy. There are no generally acceptable guidelines for surgical approach of facial arthromyalgia (Goss 1993). Surgical interventions is indicated only when nonsurgical management was unsuccessful, or when pain and dysfunction is localised to the TMJ and result in significant impairment to the patient due to intra-articular adhesions or meniscus damage (Dolwick 1997). However, TMJ surgery has not yet been studied in controlled clinical trials, therefore the benefit of surgery are still uncertain and controversial.

2.3. Summary

The aetiology of CIFP is multifactorial. It is a self-limiting condition; most signs and symptoms will not progress to more serious or long-term debilitating conditions. The diagnosis requires thoroughly history taking and clinical examination. No specific investigations can be used to confirm the clinical diagnosis. Management requires a biopsychosocial medical model which also explains and clarifies other chronic pain conditions. The natural untreated course of CIFP has not yet been elucidated. Therefore the prognostic factors cannot be specified. There are no definitive recommended treatments as all treatments have been claimed to be equal successful. Treatment should be reversible and nonaggressive based on evidence-based studies. There are many controversial issues which need to be resolved by research studies.

CHAPTER 3

PAPER-BASED FACIAL PAIN PROFORMA QUESTIONNAIRE

'Every pain has its distinct and pregnant signification, if we will but carefully search for it.' (Hilton 1950)

3.1. Introduction

The diagnosis of CFP poses a challenge to clinicians. The anatomy of the head and neck is complex, with various organs to which a variety of diseases may occur, and account for many different orofacial pains. The complexity and richness of nervous supply to head and neck region may also account for the many subtleties of pain quality that are experienced. Pain may arise from teeth, periodontium, jaws, temporomandibular joints, muscles, ligaments, nasal cavity and accessory sinuses, eyes, ears, blood vessels, and intracranially. Pain is not only a subjective experience, but also multidimensional including sensory-discriminative, motivational-affective and cognitive-evaluative components. Thus, by its nature, the diagnosis and assessment of patients with pain can be frustrating for the clinician. One difficulty for the clinician dealing with pain are the similarities and overlapping nature of signs and symptoms produced by various conditions that affect the orofacial region. In fact, the patient with orofacial pain may have a concomitant of two conditions or more, and this is similar to chronic pain in other areas (Wincent, Liden, & Arner 2003). Another difficulty is that in many patients, in particular CFP, objective physical findings to support their complaints of pain are absent. According to the traditional biomedical model, it is believed that the subjective symptoms are a consequence of tissue pathology which can be identified by using objective physical assessment, imaging, and laboratory investigation. However, dealing with CFP, clinicians must be aware of the biopsychosocial model which is an integration of the biomedical model and psychosocial factors. There are devices and instruments for the diagnosis of CFP such as jaw motion tracking, sonography of the temporomandibular joint and electromyographic recordings

of the jaw muscles. A comprehensive review indicated that the validity and utility of such instruments has not been supported by research (Clark et al. 1997). Up to date, it has been universally accepted that the accurate diagnosis of pain relies on a thorough history and careful clinical examination.

This chapter aims to present, examine, and validate the appropriateness and integrity of the Eastman Pain questionnaire for history taking, namely the Facial Pain Proforma (FPP), which is designed to lead a clinician in the process of history taking and clinical examination of CIPF. This potentially aids a clinician to reach a differential diagnosis of CIPF, so that proper management can be justified.

3.2. Development and Structure of the Paper-based Facial Pain Proforma

Generally, questionnaires have been frequently used in the analysis of chronic pain due to the multidimensional nature of pain. The Facial Pain Proforma (FPP) is a modified version of a well-established one originally developed by Professor Malcolm Harris for data collection from patients in the Facial Pain Clinic at the Eastman Dental Hospital and used for nearly 25 years. The FPP is a semi-structured questionnaire, in which the regions and areas within regions are all predetermined, but the clinician has the flexibility to move across areas and regions according to the flow of the history taking and examination performance. There are also fixed open-ended questions with no predetermined response. A meta-analysis study (Williams et al. 2002) for a review of the accuracy and precision of a depression questionnaire for the diagnosis of clinical depression indicated that the semi-structured questionnaire can be used by general practitioners to make a diagnosis of depression with high reliability. We may infer that this type of questionnaire can be beneficial for other applications. Moreover, the semi-structured questionnaire has been shown to be suitable for psychological assessment in the clinical setting. The main objective of using this questionnaire was as a means to collect the relevant data, as a foundation for a computerised questionnaire.

3.2.1. Structure of the Paper-based Facial Pain Proforma

The questionnaire consists of questions, and diagrams for pain location (see Appendix A.1). There are 2 main parts of the FPP, namely the history, and

examination. The history form is designed to enable the clinician to collect data from the patient interview. The second part is designed to lead the clinician to perform relevant examinations to support the clinical history. The development of each part is described below.

Table 3-1: Feature of history taking of the FPP

Pain history

- Present complaint
- Location including a pain drawing diagram
- Pattern of distribution
- Duration since onset
- Quality
- Intensity
- Pattern of pain (continuous/intermittent)
- Frequency
- Duration of episode
- Pattern of onset
- Progress since onset
- Sleep disturbance
- Modifying factors
 - Precipitating
 - Aggravating
 - Alleviating
- Associated symptoms and signs
- Awareness of clenching/bruxism
- Previous consultation
- Previous treatment

Past medical history

- Past major illness
- Current medication
- Pain related past and present history

Family and psychosocial history

- Psychosocial history
 - Habit including smoking, drinking, and drug use
 - Past depressive illness
 - Present depressed mood
 - calm/tense personality
 - worry of anything (to evaluate current stressor)
 - Current problems

Family history

- Family tree diagram

Parents alive, health, and relationship of parent
Partner alive, health, and relationship with the patient
Children alive, health, and behaviours
Siblings alive, health, and relationship with the patient

3.2.1.1. Part I: History taking

The history format includes pain history, past medical history, psychosocial history, and family history.

(a) Pain history

We focused on complaints which can be used to elicit the relevant pain history. The location of the pain can be used as an attribute for differential diagnosis and is shown graphically when the clinician indicates the location in a diagram. The quality and intensity of pain are asked. The duration of pain, the pattern of pain, the length of each bout of pain, the frequency of pain, the effect of pain on sleeping, and the progress of the pain are all recorded. The precipitating factor(s) of the pain are asked to see the patient's opinion about the cause of the pain and also the situation, before the pain developed. These can be used as data to assess the patient's attitude to their cause of pain and might also be used for clinical management of pain. The aggravating factors are one of the main attributes for suggesting a differential diagnosis. Examples are:

- Aggravating factors for facial arthromyalgia i.e. opening wide, yawning, talking, chewing. In fact these are factors, which used to assess jaw functioning which are the main symptoms affected by facial arthromyalgia.
- Aggravating factors for dental pain condition i.e. cold and hot food to suggest symptoms of pulpal pathology. The hard food question is used for assessing the cracked tooth condition and facial arthromyalgia because it meant to increase the force load on the joint, muscle and tooth.
- The emotional tension and fatigue are used for assessing atypical facial pain and atypical odontalgia. However, it can be used as the aggravating factors for facial arthromyalgia as well.
- Posture can be used to assess the sinus health or otherwise.

- Light and noise are used to assess the condition of tension headache, migraine.
- Weather change usually cold weather is used to assess facial arthromyalgia and trigeminal neuralgia.

(b) Past medical history

Standard past medical history questions are asked. We also add important past and present pain-related questions such as headache, neck pain, back pain, irritable bowel syndrome, and pruritis. These conditions have been observed as the conditions often occur with in chronic idiopathic facial pain (Feinmann & Harris 1984a), (Berry & Harris 1985). More uncommon conditions may also be present with facial pain such as chronic fatigue syndrome (myalgic encephalomyelitis), fibromyalgia (Aaron, Burke, & Buchwald 2000), and whiplash injury (Burgess 1991), (Aghabeigi, Feinmann, & Harris 1992). Differential diagnosis includes rheumatoid arthritis, osteoarthritis, ankylosing spondylitis, rheumatoid arthritis, diabetes and post herpetic neuralgia etc.

(c) Psychosocial history

The questions about the patient's current emotional status such as depression and anxiety and also any history of depressive illness are asked. A history of addictive substances such as cigarette, alcohol consumption cannabis and cocaine substances is included. The life style changes such as the responsibility of the patient's occupation, the patient's partner, sleeping, disappointment, and assault are asked.

(d) Family history

The major aims of a family history are to determine whether anyone has problems similar to the patient's and also to assess family relationship as a potential source of stress. Straightforward questions about family members include their health status and major life events. A patient's close relationships are often a potent source of distress or of important support. The quality of the relationship, presence of children, and health of the partner are explored. The questions of parent's relationship, parent's health is asked to find out the possibility of stressful event. The relevance of these factors will be discussed later.

3.2.1.2. Part II: Clinical Examination

This part is aimed to collect the examination data to confirm the tentative diagnosis which is drawn from the history taking. The overview features of the clinical examination are shown in Table 3-2.

Table 3-2: Feature of clinical examination of the FPP

Cranial nerve examination
Assessment of the Cranial nerves recorded as normal or abnormal
Extra oral examination
Swelling
Lymphadenopathy
TMJ examination
TMJ pain on palpation
Click or crepitus on opening and closing
Muscle pain on palpation
Mandibular movement
Opening pattern
Maximum vertical opening
Intra oral examination
General oral hygiene
Teeth diagram
Attrition
Dental caries
Periodontitis
Tenderness
Soft tissue examination
Investigation
Radiography
Haematology
Diagnosis

A standard examination includes the cranial nerves, extra oral examination, the temporomandibular joint, the muscles of mastication and related muscle of face and neck are examined, mucosal examination, and dental examination. Radiographic and laboratory investigations are performed in relevant cases. Any obvious physical injury or mucosal lesion such as ulceration, mucosal changes, which may be the cause of pain, should be ruled out by mucosal examination. Pain from dental causes such as pulpitis, periodontitis and tooth

fracture must be ruled out by a thorough dental examination. The detail of questionnaire is documented in Appendix A.1.

3.3. Validation of the Paper-based Facial Pain Proforma Questionnaire

To develop any instrument, the validity and reliability of the instrument should be tested. Validity is defined as the extent to which an instrument (i.e. the questionnaire) measures the characteristics that are of interest to the investigator. For the purpose of the FPP, content validity and criterion-oriented validity are important. Content validity requires that the items comprising the index are representative of the problem studied. This was reached by including items that have been used clinically and are repeatedly cited in the literature as objective signs of CIPF. Attributes for diagnosis of each manifestation of CIPF were identified for both quantitative and qualitative analysis. The questionnaire was validated by seeking the opinion from an expert panel. The panel inspects for the crucial elements required for the diagnosis of CIPF. Criterion-oriented validity is whether a new measure assesses the same thing as the accepted standard. The criterion measure is held to be the standard for the phenomenon of interest. The selection of a criterion is based on scientific and practical utility as well as on the quality of the measurement instrument. At present the FPP is our potential gold standard for the diagnosis of facial arthromyalgia, atypical odontalgia, atypical facial pain, and oral dysaesthesia. There have been many attempts world wide to develop the questionnaire used in history taking and examination for facial arthromyalgia. However, there is still a lack of consensus for an acceptable questionnaire for use in CIPF and other orofacial pain conditions.

The aim of this section is: (1) to validate the content of the FPP questionnaire, and (2) to retrospectively confirm the completeness of medical record using a traditional free hand history in comparison to the FPP questionnaire.

3.3.1. Materials and Methods

3.3.1.1. Content Validation

The clinical data in the FPP itemised as a questionnaire with 4 rating scales (nil, rarely, likely, always) were evaluated to establish its usefulness for the

diagnosis and management of orofacial pain patients. Three clinicians including 2 pain specialists and 1 consultant clinical psychologist were asked to evaluate the proforma. The questionnaire with the rating scale is documented in Appendix A.2.

3.3.1.2. The Completeness of Free Hand Pain History

The study has been approved by the ethics committee of the Eastman Dental Institute, University College London. The medical records which used a free hand history were examined and compared with those assisted by the FPP. The quality gradient of the free hand history taking between inexperienced and experienced clinicians was also examined by dividing clinicians into 4 groups: (1) pain specialists (PSP), (2) oral maxillofacial registrars (OMFS), (3) senior house officers (SHO), and (4) post graduate oral and maxillofacial surgery students (MSC). The orofacial pain medical records of these 4 groups between the period of January and August 2000 were taken from the medical record department by availability. The clinicians were not aware of the study. Only the first-visit history taking of orofacial pain patients were studied. The clinical data in the questionnaire rating scale as mentioned in 3.3.1.1 were listed and compared with the medical records. For each item of clinical data three values were possible – (1) recorded, (2) not recorded, and (3) not applicable.

3.3.1.3. Statistical Analysis

The occurrence of clinical data recorded from all the medical records by each group of clinicians were counted and calculated as a percentage. Fisher's Exact test statistics was used to test the difference of the experienced clinician group (pain specialists) and the inexperienced clinician group (oral maxillofacial registrars, senior house officers, post graduate students).

3.3.2. Results

3.3.2.1. Rating the Essential Data in the Facial Pain Proforma

The clinical data which were agreed among 3 pain clinicians to be the most important and useful in the diagnosis and management of orofacial pain are shown in the following table (Table 3-3).

Table 3-3: The clinical data agreed by 3 pain clinicians as the most useful in the diagnosis and management of orofacial pain patients.

Clinical Data
1. Complaint
2. Area of pain with pain drawing
3. Pain distribution pattern
4. Duration since onset
5. Quality of pain
6. Intensity of pain
7. Pattern of pain (constant/intermittent)
8. Frequency of episodes
9. Duration of bout of each episode
10. Time when pain usually come or when pain is worse?
11. How does pain affect sleep?
12. Precipitating factors
13. Aggravating factors
14. Relieving factors
15. Previous consultation
16. Progress of pain since onset
17. Psychosocial history: Drug use
18. Diagnosis
19. Treatment

However the following clinical data (Table 3-4) were agreed by only 2 of the clinicians as the most useful whereas the other clinician rated them down a step. The grading was not necessarily by the same two clinicians. The clinical data commented by the consultant psychologist as debatable parameters are distinctively showed in Table 3-5. However, these same clinical parameters were seen by both pain specialists as the most useful. One pain specialist commented that the family history and some psychosocial history data including marital status, employment status, occupation, smoking, alcohol use, and drug use may not be employed exclusively for the diagnosis but are also useful for patient management

Table 3-4: The clinical data agreed by 2 pain clinicians as the most useful in the diagnosis and management of orofacial pain patients.

Clinical Data
1. Associated symptoms and signs
2. Awareness of clenching teeth

Clinical Data
3. Previous treatment
4. Past medical history
5. Current medication
6. Pain related past & present medical history. (e.g. headache, neck ache, backache)
7. Psychosocial history: Employment status
8. Psychosocial history: Occupation
9. Psychosocial history: Smoking
10. Psychosocial history: Drinking
11. Psychosocial history: Past depressive illness
12. Psychosocial history: Present depressed?
13. Psychosocial history: Calm/tense ?
14. Psychosocial history: Worry of anything?
15. Psychosocial history: Current problems?
16. Family history: Family tree drawing
17. Examination: cranial nerve exam
18. Extra oral examination: swelling
19. Extra oral examination: lymphadenopathy
20. TMJ examination: palpation pain
21. TMJ examination: click/crepitus
22. TMJ examination: muscle pain on palpation
23. Mouth opening measure
24. Intra oral examination: Teeth
25. Intra oral examination: Mucosa
26. Radiography

The following table (Table 3-5) is the clinical data for which only the consultant psychologist commented as debatable parameters.

Table 3-5: The debatable clinical parameters ranked by the consultant clinical psychologist.

Clinical Data
1. Psychosocial history: Depressive illness in the past
2. Psychosocial history: Present depressed
3. Psychosocial history: Calm/tense personality
4. Psychosocial history: Worry of anything
5. Psychosocial history: Current problems

The clinical data which were considered by 2 clinicians including the consultant psychologist and one pain specialist to be useful, but intrusive to patients if asked at the first visit (Table 3-6).

Table 3-6: The clinical data which were seen as useful but intrusive and inappropriate in the first visit by the clinical psychologist and one pain specialist.

Clinical Data
1. Family history: Parents; their health, their alive/death, their relationship, emotional impact to patient
2. Family history: Partners; their health, their alive/death, marital relationship, emotional impact to the patient to patient
3. Family history: Children; their health, their alive/death, relationship with children, behaviour of children, emotional impact to patient
4. Family history: Siblings; their health, their alive/death, emotional impact to patient

3.3.2.2. The Completeness of Free Hand Pain History

The clinician group comprised of 5 pain specialists, 9 oral and maxillofacial registrars, 7 senior house officers, and 4 postgraduate oral and maxillofacial students. The characteristics of five pain specialists is that one academic pain expert has qualified in Medicine and Oral Maxillofacial Surgery and having experience in the facial pain practice for over 30 years. Two specialists have qualified their PhDs in the facial pain and have been practicing in facial pain clinic for about 10 years. One specialist has been doing PhD and practicing in the facial pain clinic for about 7 years. The last specialist qualified MSc in Oral and Maxillofacial Surgery and has been practicing in the facial pain clinic for about 7 years. The nine registrars are qualified in MSc in Oral and Maxillofacial Surgery and have been working from 15 to 20 years. The seven senior house officers qualified in MSc in Oral and Maxillofacial Surgery and have been working for 3 to 5 years. The four postgraduates are studying in the first year of Oral and Maxillofacial Surgery course and have work experience from 1 to 2 years. The patients' characteristics in each group and their diagnoses are shown in Tables 3-7 and 3-8 respectively.

Table 3-7: Comparison of patient characteristics among the 4 groups of clinicians.

Characteristics of patients	Pain Specialists (PSP)	Non Pain Specialists		
		OMFS	SHO	MSC
No. of records	31	12	31	19
Mean age (sd.) years	48.2 (17.0)	44.3 (15.1)	43.5 (15.1)	37.5 (16.6)
Gender (F:M)	25 : 6	10 : 2	22 : 9	14 : 4

sd. = standard deviation

Table 3-8: Comparison of frequency of the diagnoses among the 4 groups of clinicians.

Diagnosis categories	Pain Specialists (PSP)	Non Pain Specialists		
		OMFS	SHO	MSC
FAM	9	5	15	7
DDWR	1	1	nil	nil
OA	1	nil	nil	1
AFP	5	3	5	4
AO	5	nil	4	1
OD	nil	nil	1	nil
TN	nil	1	1	nil
TA	nil	nil	nil	1
PP	nil	1	nil	nil
AFP/AO	nil	nil	1	nil
OD/AFP	1	nil	nil	nil
AFP/FAM	nil	nil	nil	1
FAM/AO/AFP	1	nil	nil	nil
FAM/TN	1	nil	nil	nil
Nil Diagnosis	4	1	4	3
^a Inconclusive	3	nil	nil	nil
Inappropriate	nil	nil	nil	1 ^b

a: Inconclusive diagnosis: a patient was referred for further consultation or awaiting for investigative results.

b: Inappropriate term due to using "TMJ clicking due to occlusal disturbance" for the diagnosis.

The following table (Table 3-9) shows a break down of the clinical data recorded in the patient records.

Table 3-9: Comparison of the occurrence as a percentage of clinical data in the 4 groups of clinicians.

Clinical Data	PSP (n=31)	OMFS (n=12)	SHO (n=31)	MSC (n=19)
complaints	100.0	100.0	96.8	84.2
area of pain	100.0	100.0	96.8	78.9
pain distribution	96.8	100.0	87.1	44.4
duration since onset	96.8	100.0	90.3	68.4
quality of pain	80.0	45.5	71.0	55.6
constant or intermittent	87.1	27.3	64.5	42.1
frequency of episode	40.0	9.1	26.7	0.0
duration of each episode	40.0	18.2	26.7	12.5
time when pain start or become severe	29.6	10.0	33.3	31.6
progress since onset	19.4	33.3	22.6	15.8
affect to sleep	50.0	36.4	51.6	50.0
precipitating factors	71.0	16.7	38.7	42.1
aggravating factors	83.3	66.7	74.2	47.4
relieving factors	86.7	33.3	71.0	31.6
associated factors	80.6	8.3	51.6	52.6
clenching awareness	9.7	0.0	9.7	10.5
previous consultation	58.1	50.0	38.7	31.6
previous treatment	58.1	66.7	35.5	31.6
past medical history	100.0	83.3	96.8	100.0
current medication	100.0	75.0	87.1	68.4
pain related past and present	75.9	45.5	32.3	21.1
marital status	93.5	58.3	77.4	57.9
employment	96.8	25.0	74.2	52.6
smoking	93.5	91.7	83.9	68.4
drinking	93.5	91.7	83.9	68.4
drug use	0.0	0.0	0.0	0.0
depressive illness	45.2	0.0	12.9	5.3
present depressed	50.0	8.3	19.4	0.0
calm/tense personality	35.5	8.3	29.0	5.3
worry	32.3	0.0	22.6	0.0
current problem	19.4	16.7	19.4	15.8
family tree drawing	73.3	25.0	38.7	42.1
parent details	73.3	16.7	74.2	78.9
partner details	62.5	10.0	48.0	40.0
children details	69.6	18.2	61.9	50.0
sibling details	57.1	8.3	54.8	47.4

Clinical Data	PSP (n=31)	OMFS (n=12)	SHO (n=31)	MSC (n=19)
cranial nerve exam	51.7	18.2	61.3	57.9
extra oral examination: swelling	48.4	41.7	48.4	42.1
extra oral examination: lymphadenopathy	36.7	50.0	35.5	26.3
TMJ pain on palpation	71.0	40.0	80.6	21.1
TMJ click/crepitus	32.3	63.6	74.2	57.9
masticatory muscle pain on palpation	30.0	50.0	67.7	5.3
mandibular movement	19.4	27.3	54.8	15.8
opening range	61.3	36.4	74.2	26.3
intra oral examination: teeth	74.2	83.3	93.5	63.2
intra oral examination: mucosa	35.5	50.0	74.2	47.4
x-ray interpretation	40.0	58.3	74.2	31.6
diagnosis recorded	77.4	91.7	83.9	84.2
treatment recorded	100.0	100.0	96.8	78.9

The following table (Table 3-10) shows the clinical data which were at least 20% different between the possible 2 groups.

Table 3-10: Clinical data which were at least 20% different between the possible 2 groups.

PSP vs. OMFS	PSP vs. SHO	PSP vs. MSC	OMFS vs. SHO	OMFS vs. MSC	SHO vs. MSC
Positive	Positive	Positive	Positive	Positive	Positive
quality	cons./inter.	area	previous tx.	area	distribution
cons./inter.	precipitating F.	distribution	Negative	distribution	duration
frequency	associated F.	duration	quality	duration	cons./inter.
bout of pain	previous tx.	quality	cons./inter.	previous tx.	frequency
time of pain	related pain	cons./inter.	time pain	related pain	aggravation F.
precipitating F.	employment	frequency	precipitating F.	smoking	relieving F.
aggravating F.	depressive ill	bout	relieving F.	drinking	employment
relieving F.	depressed	precipitating F.	associated F.	lymph node	calm/tense
associated F.	family. tree draw	aggravating F.	employment	muscle pain	worry
current med.	Negative	relieving F.	calm/tense	teeth exam.	TMJ pain
related pain	click/crepitus	associated F.	worry	x-ray	muscle pain
marital status	muscle pain	previous con.	parent details	treatment	mandibular move
employment	mandibular move	previous tx.	partner details	Negative	opening range
depressive ill	x-ray	current med.	child details	time of pain	teeth exam.
depressed		related pain	sibling details	precipitating F.	mucosal exam.

PSP vs. OMFS	PSP vs. SHO	PSP vs. MSC	OMFS vs. SHO	OMFS vs. MSC	SHO vs. MSC
calm		marital status	CNS exam.	associated F.	x-ray
worry		employment	TMJ pain	employment	
family tree draw		smoking	mandibular move	parent details	
parent details		drinking	opening range	partner details	
partner details		depressive ill	mucosal exam.	child details	
child details		depressed		sibling details	
sibling details		calm/tense		CNS exam.	
CNS exam.		worry			
TMJ pain		family. tree draw			
opening range		partner details			
Negative		TMJ pain			
click/crepitus		muscle pain			
muscle pain		opening range			
		treatment			
		Negative			
		click/crepitus			

Positive means that the clinical item was recorded in medical record of the first group at least 20% more than the second group.

Negative means that the clinical item was recorded in medical record of the first group at least 20% less than the second group.

F. = factor, tx. = treatment, cons. = constant, inter. = intermittent.

The occurrence of each clinical data item was compared between the experienced and inexperienced group using Fisher's exact test statistic. The following table (Table 3-11) illustrated the clinical data which their occurrences were significantly different between the experienced and inexperienced clinician group at $P < 0.025$.

Table 3-11: Clinical data which the occurrences are significantly different between the experienced and inexperienced group ($P < 0.025$).

Section	Clinical data
Pain history	constant/intermittent precipitating factors relieving factors associated factors pain related past and present
Past medical history	current medication

Section	Clinical data
Psychosocial history	marital status employment worry depressive illness present depressed
Family history	family tree drawing
Extra oral examination	TMJ click/crepitus*

* The occurrence in the experienced group is less frequent than in the inexperienced group.

The empirical sensible arbitrary cut off at 70% and 50% are chosen to assess the performance of all 4 clinician groups and to evaluate the clinical data which are frequently recorded. The following Table 3-12 illustrated the clinical data found in 70% of the medical records in each group.

Table 3-12: The clinical data found to be recorded in the majority (=>70%) of the medical records rank in the order from the highest to the lowest.

PSP	OMFS	SHO	MSC
1.complaint	1.complaint	1.complaint	1.past medical history
2.area of pain	2.area of pain	2.area of pain	2.complaint
3.past medical history	3.pain distribution	3.past medical history	3.diagnosis
4.current medication	4.duration	4.treatment	4.area of pain
5.treatment	5.treatment	5.teeth examination	5.parent relationship
6.pain distribution	6.smoking	6.duration	6.treatment
7.duration	7.drinking	7.pain distribution	
8.employment	8.diagnosis	8.current medication	
9.marital status	9.past medical history	9.smoking	
10.smoking	10.teeth examination	10.drinking	
11.drinking	11.current medication	11.diagnosis	
12.constant/intermittent		12.TMJ palpated pain	
13.relieving factors		13.marital status	
14.aggravating factors		14.aggravating factors	
15.associated factors		15.employment	
16.quality of pain		16.parent relationship	
17.diagnosis		17.click/crepitus	
18.pain related past and present		18.maximum opening	
19.teeth examination		19.mucosal examination	
		20.quality of pain	
		21.relieving factors	

PSP	OMFS	SHO	MSC
20.family tree drawing			
21.parent relationship			
22.precipitating factors			
23.TMJ palpated pain			

The following Table 3-13 shows the clinical data recorded in between 50 to 70% of the medical records.

Table 3-13: The clinical data found to be written between => 50% and <70% of the medical records rank in the order from the highest to lowest.

PSP	OMFS	SHO	MSC
1.children details	1.aggravating factors	1.muscle pain	1.duration since onset
2.partner details	2.previous treatment	2.constant/intermittent	2.current medication
3.opening range	3.click/crepitus	3.children details	3.smoking
4.previous consultation	4.x-ray interpretation	4.CNS examination	4.drinking
5.previous treatment	5.previous consults	5.sibling details	5.teeth examination
6.sibling details	6.lymphadenopathy examination	6.mandible move	6.marital status
7.CNS examination	7.muscle pain	7.affect to sleep	7.CNS examination
8.affect to sleep	8.mucosal examination	8.associated factors	8.click/crepitus
9.present depressed			9.quality of pain
			10.associated factors
			11.employment
			12.affect to sleep
			13.children details

The following Table 3-14 shows the clinical data recorded in more or equal than 70% and 50% of medical records of all groups.

Table 3-14: The clinical data found to be written in more than half of the medical records of all 4 groups.

Clinical data	
>= 70%	<ol style="list-style-type: none"> 1. complaints 2. area of pain 3. past medical history 4. diagnosis 5. treatment
>= 50% and < 70%	<ol style="list-style-type: none"> 1. duration 2. current medication 3. marital status 4. smoking 5. drinking 6. teeth examination

It is noticeable from this data that:

- the style of record varied for each group. For instance a detailed narrative style as dictated by the patient verbal often lacked essential clinical data.
- illegibility was a problem especially in the specialists' records.
- abbreviations which were not universally understandable.
- psychosocial data was ignored by the OMFS specialists.
- OMFS specialists took thorough past medical history compared to other clinical data in their histories.
- SHOs and MSC. students acquired more psychosocial data than the OMFS specialists.
- Pain specialists acquired all of the useful data for orofacial pain. However they used abbreviations to identify negative findings such as use NAD (nil abnormal detected) to cover several aspects - e.g. pain, tenderness and noise of the TMJ – recorded as one NAD.
- some data were not recorded such as the diagnosis. This will cause difficulty for other clinicians especially for the follow up visit. It also raises the question as to whether a diagnosis could not be made, or the failure to record was simply an oversight i.e. due to clinical pressure or forgetfulness.

- some negative findings were not recorded. For instance, TMJ and extra oral examination negative finding were frequently not recorded and there was no mention of the chief complaint.

3.3.3. Discussion

The content validity study of the FPP demonstrated that the panel of experts reached a consensus on the clinical parameters of the pain history. The panel also agreed on the clinical data in the examination except the consultant psychologist did not comment on the examination data since he felt less able to do so. However, the clinical data in the psychosocial history was commented on by the psychologist as debatable and not to be used for the diagnosis. Those data of the marital, parental, children and sibling relationship were seen by both the psychologist and one pain specialist as being intrusive. Their histories were varied demonstrating clinical bias and personal timidity. Others felt strongly that this is essential to elicit the family history details at the first visit otherwise this data would not appraised in future next visits. Family relationships appear to be one of the major stressors associated with chronic pain. The controlled clinical study (Schwartz, Slater, & Birchler 1996) demonstrated that marital conflict can increase subsequent pain behaviour in the pain couple. Another controlled clinical study of the recurrent headache in the pre-school age children indicated that there was an association between family relationships and environment to the prevalence of tension type headache in children (Aromaa et al. 2000). Thus there is a need to explore this issue in the future in order to manage the chronic pain patient. The compliant patient accepts the need for thorough exploration in order to tackle her/his problem. To be intrusive or not remains an issue of subjectiveness. Perhaps there is a need to explain the need for this data with the orofacial pain patient. From this study, the panel of 3 specialists was too small to validate the questionnaire adequately from a clinical point of view. However it strongly illustrates that data can be lost by individual bias when using a free hand history because of prejudice or timidity.

The audit study of completeness of the medical records demonstrated that there was a discrepancy in the clinical data recorded in medical records and compared to those of the FPP in almost all the data sections. The omission of clinical data in medical records were widely revealed in other studies in various

clinical settings (Dawes 1972), (Shiffman, Brandt, & Freeman 1997), (Luck et al. 2000). It is clear that the documentation was more thorough for psychosocial history data using the FPP. The discrepancy of clinical data recorded among the 4 groups of the free hand medical record is varied. In general, the pain specialists captured more clinical data than the others in almost all aspects except some examination data and radiographic interpretation. The senior house officers also capture more clinical data and the students performed the worst in capturing clinical data by free hand history taking. While half of the experienced clinicians' records tended to focus on the history data including the pain history, the psychosocial history, the past medical history, and the family history rather than on the examination data. The inexperienced clinicians' records tended to focus on examination data as seen in the senior house officers group. Tables 3-10 shows that senior house officers, maxillofacial surgeons, and students recorded more frequent in "TMJ clicking/crepitus examination", "mandibular movement", and "muscle palpation" which shows significant difference in "TMJ clicking/crepitus examination" (see Table 3-11). Table 3-12 lists the clinical data that being recorded in the majority ($\geq 70\%$) of medical records and it shows that there were more clinical items captured in the medical records of pain specialists than senior house officers who tended to focus on examination data. The oral maxillofacial registrar's medical records lacked many clinical data items when compared to those of the pain specialists and the senior houses officers (Table 3-10). The main significant differences between the experienced (the pain specialists) and inexperienced group (the oral maxillofacial registrars, the senior house officers, and the students) are the pain history and the psychosocial history. The pain history data are those of the modifying factors, the associated factors, the precipitating factors, and constant/intermittent pattern of pain (Table 3-11). The psychosocial history data are those of present depressed, depressive illness history, employment, and marital status. In addition, the occurrence of the family tree drawing, the current medication, and the TMJ noise examination are also different among experienced and inexperienced group. The discrepancy of the clinical data found in medical records among 4 groups of clinician is quite high. Table 3-14 highlights this observation by picking the clinical data which are recorded in the majority ($\geq 70\%$) of the medical records in consensus of all 4 groups. It showed that only major clinical data including the complaint, the pain area, the

past medical history, the diagnosis, and the treatment were picked. Therefore, there is a need to reinforce the performance of history taking of the orofacial pain patient to reach the same minimum standard.

Generally, the proforma captures more clinical data than those of medical records. This does not necessarily lead to more diagnostically important conclusions. We should, also, be careful not to conclude too hastily that data were actually missing from the medical records. With the pain specialists' medical records the data may not be recorded because they were negative findings or they were irrelevant in the context of chief complaints. The history of inexperienced clinicians such as post graduate students usually demonstrated an uncontrolled pattern, narrative led, directed by patients' own story. Also inexperienced clinicians tend to miss vital facts and the diagnosis because they lacked the crucial knowledge of the condition and skills in performing history taking. This raises the possibility of some failure in their undergraduate education.

The study also indicated the need for medical education and audit in pain management especially in the history taking of the chronic orofacial pain patient, since it is crucial for diagnosis and treatment planning. Such education must emphasize the multidimensional perspective of pain. Social and emotional problems which are important in establishing a comprehensive diagnosis must not be overlooked. The proforma serves as a clinical guideline for students and clinical novices in the same way as the use of check lists can help residents in internal medicine to perform appropriate preventive health measures at a significantly higher rate than those who did not (Duggan, Starfield, & DeAngelis 1990).

The experienced clinician may find that the semi-structured proforma is rigid and unfriendly. The other down side of the proforma is that it does not provide a database to record selected data directly into computerised database.

Another notable limitation of this study derives from the observer bias (the investigator, P.C.) is unquestionable but unavoidable because of non availability of support for manual retrieval. In addition, there is a discrepancy in the quantity of the medical records among the 4 clinician groups.

3.3.4. Conclusions

The study clearly demonstrated that free hand history was unreliable except when undertaken by experts. Even then, the record is not complete. There was often a leap from the history to diagnosis, possibly by experienced intuition. Inexperienced clinicians benefit from a proforma but even then with all the required history the correct diagnosis is not guaranteed. Also inexperienced clinicians were often patient-lead when taking history in the belief that it was appropriate. The outcome could be irrelevant data gathered with a misleading diagnostic conclusion. An unexpected discovery was bias by experienced specialist clinician based on prejudice and timidity. The prejudice is that this pain is not psychological therefore one must not explore the psychological issue. The medically trained surgeon would produce an excellent history but again overlook important pain-related features.

Ideally some means of collecting the essential data to formulate diagnoses will overcome these problems. During this investigation the patients' attitudes could not be appraised as it was a retrospective study. The recommendation is that the paper-based FPP should be transferred to a computerised one with a user friendly interface and a diagnostic database for orofacial pain patients.

CHAPTER 4

ELECTRONIC MEDICAL RECORD: THE ELECTRONIC EASTMAN PAIN PROFORMA

4.1. Introduction

A medical record or a patient record is a collection of patient specific data relating to a clinical history. The main purpose of a medical record is to store clinical data and facilitate its retrieval. Medical records also serve as a means for communication among health care providers in order to support patient management. The function of medical records can be clearly seen in medicine. For instance, a hospital doctor sees patients in the ward, and then records patients' signs and symptoms, orders a laboratory test, and instructs nurses about medication to administer. Nurses then act upon this instruction and administer the appropriate intervention and drug to the patient. The procedure of recording the patient case notes is influenced by the evolution of medical care and reflects the changing nature of the doctor-patient relationship.

In this chapter we begin with a review of the medical record in general including evolution, structure, and role in health care, following by the investigation of the need of change from the paper-based to electronic medical record. Then the electronic medical record is reviewed exclusively including the benefits, the constraints, the clinical status, the current systems, and the governmental role in supporting the electronic medical record. The last part of this chapter presents our study on the development of the Electronic Eastman Pain Proforma (EEPP) which is an electronic medical record for orofacial pain history taking. In our work we define the potential users, the system requirements, and the works in the Facial Pain Clinic. Then we describe the details of the EEPP including the system database modelling, the system functionality and user

interface. The final part is the clinical study explores the acceptability of the EEPP to patients and clinicians in the Facial Pain Clinic.

4.2. Evolution of Medical Records

The medical record has a long history traced back to the fifth century B.C., the period of Hippocrates who recorded the descriptions of events that preceded disease rather than real causal relationships. He recorded his observations in a purely chronological order. In early civilisation, records were handed down by the spoken rather than by written word. According to the review of Heard et al. (2002), the earliest individual patient record in United Kingdom was found in St. Bartholomew's Hospital and can be dated back to 1123 AD. in the reign of Henry I who established the first public records office in England. By the mid nineteenth century the doctors in United Kingdom usually keep their patients' records with them in case books, one book for each year, with the patients' names in alphabetical order. As mentioned by Davis (2002), the methods of data collection in medical records in the Scottish asylums before 1880 were almost always disparate, idiosyncratic and inconsistent in response to ad hoc demand rather than systematic. Although the printed forms produced by commercial suppliers were widely introduced in the Royal Edinburgh Asylum in 1887 to achieve regularity and uniformity, the records were still frequently incomplete due to the doctors' resistance on the ground of freedom of individual. In 1907 St. Mary's Hospital started a system of unit notes focusing on the patient as the centre for the record compilation. Similarly, in the United States, in the late nineteenth century, the patient medical notes recorded by each doctor were kept in their personal leather-bound ledger in chronological order. The notes belonging to a single patient could be pages apart, depending on the time intervals between visits. In 1907, the Mayo Clinic personal medical records were replaced by the patient-centred medical records. At that time, the medical records acted as a personalised "lab notebook" in which clinicians recorded their observations, what they had done to the patient, and their plan to remind themselves when they next saw the same patient (Shortliffe 1999). There were no compulsory requirements and assumptions to complete a medical record nor to use it. The role of a medical record formerly was similar to a memorandum, that is informal, free style text, and unformatted. Thus, it is not a standard record as required by modern medicine. In 1920, the Mayo Clinic

management agreed upon a minimum set of data for a patient medical record which is the foundation of the present medical record.

4.3. Structures of Medical Records

Since the beginning of the standard medical record, its structure has two main categories; (1) the Time-Orientated Medical Record, and (2) the Source-Orientated Medical Record. The Time-Orientated component comprise the clinical details ordered by the encounter date of clinician and patient (see Figure 4-1) whereas in the Source-Oriented Medical Record, the clinical details are ordered according to the heading of visits, radiography reports, and laboratory reports (see Figure 4-2). Even though the medical record has evolved a standardised format, these structures of the medical record do not provide a clear picture of patient problems, especially in complicated cases with more than one complaint. In the 1960s, Weed proposed the Problem-Orientated Medical Record (POMR) (Weed 1971). Weed's aim was to bring to the attention of the medical profession the medical record and establish the idea of problems and a problem list as central features of the medical record. Both an initial note and a progress note were recorded per problem according to the SOAP structure. SOAP is an acronym, which stands for;

- subjective (S); a complaint as phrased by the patient
- objective (O); the findings of physicians
- assessment (A); the test result and conclusion such as a diagnosis
- plans (P); the medical plan e.g. treatment, prescription, policy

Several health care professionals have adopted POMRs. These full-scale are cumbersome, and require a disciplined approach for clinicians to record data (see Figure 4-3). Clinicians have been reluctant to adopt such an approach which would incur additional constraints on their time and increased workload. There is a criticism about SOAP regarding the terms, subjective and objective, which Donnelly and Brauner (1992) criticised as a dichotomous concept. Subjective inevitably implies insubstantiality, something “existing only in the mind”. Objective, on the other hand, means having an “actual existence or reality”. Labelling what patients say as “subjective” and what doctors and laboratories find as “objective” tends to minimise the reality of the patient's world and exaggerate the reality of the doctor's. The POMRs have not been

widely accepted in the form in which they were originally conceived. Some health care institutions have adopted some form of POMR (Donnelly & Brauner 1992), (Hayes 1993), (Rector, Nowlan, & Kay 1991). The following are examples of typical medical record as mention above.

Time-Orientated Medical Record

10/07/2003:

pain, stiffness, warmth, and swelling of hands, wrists, knees, and elbows; difficult to type, hardly get out of bed and do her morning chore. She has fever, malaise, and weakness.

Examination; she is pale, body temperature is 38.2 °C. swelling, tenderness, redness, and warmth of most proximal interphalangeal joints, the metacarpophalangeal joints, the wrists, knees, and elbows. Normal eye, face, lung, and heart. BP is 120/80.

Full blood count shows mild anaemia, urinalysis is normal, rheumatoid factor is positive, ANA is negative, VDRL is negative, ESR is high at 40mm/hr.

Chest x-ray is normal, x-ray of the involved joints show bone demineralisation, ECG is normal

Medication; aspirin 650 mg tds, rest and physiotherapy. The use of gold or methotrexate will be considered.

19/07/2003:

less pain, no fever, improved mobility of joints. Start the course of physiotherapy today.

Figure 4-1: An example of typical Time-Orientated Medical Records, modified from (Cutler 1998).

Source-Orientated Medical Record

Visits:

10/07/2003:

pain, stiffness, warmth, and swelling of hands, wrists, knees, and elbows; difficult to type, hardly get out of bed and do her morning chore. She has fever, malaise, and weakness.

Examination; she is pale, body temperature is 38.2 °C. swelling, tenderness, redness, and warmth of most proximal interphalangeal joints, the metacarpophalangeal joints, the wrists, knees, and elbows. Normal eye, face, lung, and heart. BP is 120/80.

Medication; aspirin 650 mg tds, rest and physiotherapy. The use of gold or methotrexate will be considered.

19/07/2003:

less pain, no fever, improved mobility of joints. Start the course of physiotherapy today.

Laboratory tests:

10/07/2003:

Full blood count shows mild anaemia, urinalysis is normal, rheumatoid factor is positive, ANA is negative, VDRL is negative, ESR is 40 mm/hr.

Radiography:

10/07/2003:

Chest x-ray is normal, x-ray of the involved joints show bone demineralisation, ECG is normal.

Figure 4-2: An example of Source-Orientated Medical Record, modified from (Cutler 1998).

Problem-Orientated Medical Record

Problem1: Painful joints

10/07/2003:

S: pain, stiffness, warmth, and swelling of hands, wrists, knees, and elbows; difficult to type, hardly get out of bed and do her morning chore.

O: swelling, tenderness, redness, and warmth of most proximal interphalangeal joints, the metacarpophalangeal joints, the wrists, knees, and elbows. Normal eye, face, lung and heart. BP is 120/80. Chest x-ray is normal, x-ray of the involved joints show bone demineralisation, ECG is normal

A: Rheumatoid arthritis

P: aspirin 650 mg tds. Physiotherapy, gold and methotrexate will be considered.

10/07/2003:

S: Less pain, no fever, improved mobility of joints.

O: Less tenderness, Body temperature 36.5 C. Start the course of physiotherapy today.

Problem 2: Fever

10/07/2003:

S: She has fever associated with the joints pain.

O: Body temperature 38.2 °C

A: inflammation of joints

P: aspirin 650 mg tds.

19/07/2003:

S: no fever

O: body temperature is normal

P: off aspirin

Problem 3: Anaemia

10/07/2003:

S: general malaise, weakness

O: pale mucosa, Normal lung, and heart. BP is 120/80. Full blood count shows mild anaemia, urinalysis is normal, rheumatoid factor is positive, ANA is negative, VDRL is negative, ESR is high at 40mm/hr.

A: haemolytic anaemia secondary to Rheumatoid arthritis

P: aspirin 650 mg tds. for Rheumatoid arthritis

19/07/2003:

S: no malaise and no weakness.

O: no sign of pale.

A: anaemia resolved

Figure 4-3: An example of Problem-Orientated Medical Record, modified from (Cutler 1998).

Most current medical records are an integration of problem orientated, time orientated, and source orientated. Medical records are categorised according to complaints, history of complaints, past medical history, social history, family history, clinical examination, laboratory tests, radiography investigation, problem list, and assessment of problems and plan. Within each section, data typically are organised in a chronological order. This is the structure of medical record especially in the first encounter with the patient. In follow up visit, a modified SOAP is a prominent characteristic.

4.4. Roles of Medical Records

In general, a medical record is an essential support for patient care. However, developments in health care and social evolution have made this task more complex. The roles of medical records are summarised as follows:

- Supporting patient care: The main objective of the medical records is to support patient care.
- Auditing: To determine the effectiveness of treatment and to monitor the adequacy of the care provided.
- Clinical decision making: It can be integrated with the decision support system and other resources to support the clinician's decision.
- Sharing data among health care providers for communication: Patients' clinical data are used to share and convey to other clinicians, for instance the doctor's order is passed to the nurse.
- Learning resource for health care providers: A valuable resource for other clinicians to learn the diagnosis work up and treatment of diseases.
- For medico-legal issues: The medical records are evidence of the care provided.

- Supporting billing and reimbursement and to analyse cost-effectiveness.
- Supporting research: Medical records can be used to monitor health care or identify risk factors of the population by epidemiologic studies and to assess trends in chronic disease. Also they can be used to determine the cost effectiveness of clinical managements and to monitor of care.

4.5. The Need for a Revolution in Medical Recording

There have been considerable developments in medicine in terms of advances in diagnostic instruments, medication, and treatment methodology. Medical institutes aim to maintain a collective record of every patient encountered in the form of medical record to facilitate patient care. This needs to change from traditional paper-based medical records to new progressive medical records in order to keep up to date and cope with the progress of other fields in medicine.

4.5.1. Inadequacies of the Paper-based Medical Record

Modern health care is information intensive. A vast amount of medical knowledge has accumulated. New subspecialties are born, leading to a need to co-operate in multidisciplinary teams. Medical technology produces new interventions which lead to prolonged patient life and hence prolonged care management. Additionally, the natural history of some medical conditions is chronic, such as degenerative joint condition (osteoarthritis) and diabetes, which leads to long time care management. The results of these are large patient records and a growing requirement for communication between health care providers. In 1989, the Academy of Medicine in the United States appointed a Committee to examine the problems with the existing medical record systems and to propose actions and research for improvement. This Committee criticised weaknesses of paper-based medical records as follows (Dick & Steen 1991);

- Patient data are scattered among a variety of sources.
- The content is often free text; hence data are possibly missing, incomplete, ambiguous, illegible, and inaccurate.

- The format of paper-based medical record had poor organisation that leads to ineffective and time-consuming use.
- The paper-based medical record can be in one place at a time. It may not be available or even be missing.
- The real integration of information cannot be achieved when a paper-based medical record is used.
- For supporting clinical trial, the contents need to be transcribed from medical records to computerised databases for scientific analysis. This approach is laborious, prone to errors, and increasingly difficult in retrospective research.
- The paper-based record can not be interactive with users to promote patient care in the form of reminders, warnings, or advice.

Many studies have examined the quality of patient record content as depicted in Table 4-1.

Table 4-1: List of studies of the quality of paper-based medical records

Authors	Objective	Study designs and Samples	Results
Tufo and Speidel (1971)	To evaluate record availability, missing data, record of laboratory results, quality of physician narrative, and data collected for general health evaluation.	1149 patient visits in 5 outpatient U.S. Army facilities.	<ul style="list-style-type: none"> • 11% of patients had no past medical data available. • 5-20% of charts had information missing of which 75% of missing data were laboratory test results or radiographic reports, and 25% of missing data were lost, incomplete or illegible data from previous visits. • 13-79% of laboratory results were not placed in the record. • 10-49% of visits did not have a well-defined problem in the record. • 40-73% of records did not have evidence of general medical information useful for preventive medicine.
Dawes (1972)	To determine the completeness of clinical data in general practices in	1628 medical records were randomly from 8 practices of	<ul style="list-style-type: none"> • 10% of patient ages were not recorded.

Authors	Objective	Study designs and Samples	Results
	the United Kingdom.	single-handed and partnership types.	<ul style="list-style-type: none"> • 30% of episodes had no therapeutic agent recorded; of those recorded, 75% were missing the amount of prescribed, and 80% were missing dosage. • 40% of episodes had no diagnosis recorded. • 60% of males and 77% of females had no occupation recorded. • 99% of males and 21% of females had no marital status recorded.
Bentsen (1976)	To assess the validity of data in the information system of the family medicine clinics.	A single blinded clinical controlled study by observation of problems encountered from 59 patients compared between experienced clinicians and residents.	<ul style="list-style-type: none"> • 41% of problems identified by observers were not recorded by residents. • the residents tended to miss social (71%) and emotional problems (52%).

Authors	Objective	Study designs and Samples	Results
Romm and Putnum (1981)	To assess the agreement of recorded document and verbal content of the physician-patient encounter.	55 patients encounters in general medicine clinics.	Percent agreement between record and observation of encounter: <ul style="list-style-type: none"> • 29% for other medical history • 66% for therapy • 71% for information related to current illness • 72% for tests • 73% for impression/diagnosis • 92% for chief complaint
Seltzer and McDermott (1999)	To observe the number of medical history inconsistencies when the interview technique was standardised but the time interval between acquisition of information was prolonged.	100 consecutive medical records of the patients who attended the private practice exclusively related to surgical disease of breast.	<ul style="list-style-type: none"> • 66% of patients had at least one significant data omission in their history.
Luck et al. (2000)	To evaluate the validity of patient chart abstraction by comparing with the standardised patients.	20 randomly selected general internal medicine residents and attending faculty physicians at the primary care clinics of 2 Veterans Affairs Medical Centres blindly	<ul style="list-style-type: none"> • False positive rate of 19% were noted in the chart records with half of them was the physical examination. • The specificity (the proportion

Authors	Objective	Study designs and Samples	Results
		evaluated and treated actor-patients (standardised patients).	<p>of true negative cases) of chart abstraction for necessary care is 81% and sensitivity (the proportion true positive cases) is 70%.</p> <ul style="list-style-type: none"> • The sensitivity of the diagnosis is very low at 48%.

4.5.2. Emerging Technologies Supporting Electronic Medical Records

In this section the computerised technologies are discussed on their possibilities for the supporting role in the development of electronic medical records. The involved technologies are databases, computer hardware, the development of communication between computerised systems, image processing, and standardised medical vocabulary to facilitate communication.

4.5.2.1. Databases

Computers are excellent at storing and retrieving data. The database is the core function of electronic medical records systems that utilise and process data. There are a number of database systems used in health information. These databases systems are based on different technologies, different architecture, come from different vendors and use different interface and query languages to archive and retrieve data. At the present there are weaknesses in database management systems for optimally storing and retrieving the full range of patient data. Relational database management systems are widely used in most computers and can support electronic medical record systems to accommodate complex medical data. The technology of standards for linking different database systems such as ODBC (Open DataBase Connectivity) which permits the exchange of diverse data structure is implemented in the relational database management system. Hence, emerging technologies have the capability to establish a link between diverse data repositories, improve security access, maintain data integrity, and provide accuracy and consistency of medical data.

4.5.2.2. Workstations

User interaction has changed to be more easy and convenient as computers have developed. Terminals with data entry by pointer/selector devices e.g. mouse, touch-screen, light-pen, or voice can now be used for data input and retrieval. Hand-held computers or other similar semiportables are employed to facilitate either manual or voice entry of data into electronic medical records. These relatively portable devices can be used at the patients' bedside by practitioners. Also the capacity of computers for storing and processing the data

is much higher than formerly. This allows the computer to manage large data such as medical imaging, and sound.

4.5.2.3. System Communication

Technologies to support communications are evolving which affect the human computer interaction. Of great significance is the internet and intranet in which single clinical workstations and various health care units and clinical resources are able to connect as a network. This transition to networks will have wide-ranging implications for improving health care because it will promote working at the point of care. Data can be acquired from any source in the network into the working computer including the electronic medical records.

4.5.2.4. Text Processing and Image Processing and Storage

To establish a patient summary report, users need to retrieve all relevant information stored in the database. This involves the use of formal query languages such as SQL (Structure Query Language) to search for the data. Such languages require training beyond typical clinical expertise. Natural-language interfaces or the ability of the computer system to selectively extract meaning from textual data has been the subject of experiments in laboratories. Picture Archiving and Communications Systems (PACSs) are technologies devised for digital image management. PACSs permit the electronic storage, transmission, and display of medical images throughout a medical facility. Initially, there was the problem of incompatibilities of equipments from different manufacturers. At present a standard called DICOM (Digital Imaging and COmmunications in Medicine) was developed by the American College of Radiology - National Electrical Manufacturer's Association (ACR-NEMA) for communications between medical imaging devices. The image can be viewed in the same time by two or more doctors at a single point or multiple points in the hospital network. Imaging systems in the near future will eliminate concerns about the current status or location of an image, either missing or in transit. Electronic medical records systems of the future, when appropriately linked to PACSs, will allow health care professionals to view images at any computer workstation in the network.

4.5.2.5. Vocabulary Standards

There are discrepancies in clinical data exchange and terminology. Efforts to develop data exchange standards and vocabulary standards have been made. Currently, there are several standards for data exchange such as HL 7 (Health Level 7), a standard from the American Society for Testing and Materials (ASTM). The vocabulary standard developments which are relevant to electronic medical records include the Systematised Nomenclature of Medicine (SNOMED) from the College of American Pathologists, the Clinical Terms (or Read Codes) used by the National Health Service (NHS) in the United Kingdom, SNOMED CT (UK edition) a combine version of SNOMED and Clinical Term which is being implemented instead of the Clinical Term, and Unified Medical Language System (UMLS) by National Library of Medicine (NLM) in United State.

4.6. The Electronic Medical Records

The increasing demands of well-structured, accessible patient data, and integrated medical records in combination with advanced information technology and telecommunications have stimulated interest in the development of the electronic medical record; this can be clearly seen in two powerful developing western countries, the United States and the United Kingdom. There is substantial enthusiasm for automating medical records especially in the Academy of Medicine in the United States. In 1989, the committee appointed by the Academy reported problems with existing medical record systems and proposed action/research for improvement (Dick & Steen 1991). The literature review in this report did not reveal any substantial documentation of strengths of paper-based medical records but summarised the weaknesses in the paper-based medical records as previously mentioned in section 4.5.1. In the United Kingdom, the Information Management Group (IMG) of the NHS Executive decided to explore the possibility of the national electronic medical record by supporting a three year project of Electronic Patient Record Programme in 1993 (see detail in section 4.6.2).

4.6.1. Summarising the Potential Benefits

An electronic medical record offers many potential advantages such as the following:

1. **Simultaneous access to patient data in the clinical setting.** More than one person can access the record at the same time from any place. At present, a paper-based record is a mobile object that can be carried to the working place. The clinician can take the paper-based record from reception to the consultation room, the treatment room, and to the bedside. If electronic medical records were implemented in their full capacity, in the future, a large number of workstations or hand-held computers connected to a network is required. The way of working would change by just turning on a computer at the point of need and bulky patient folders would be redundant.
2. **Legibility:** One of the main problems of paper-based medical records, apart from missing patient medical file, is poor legibility. This is important because correct communication needs correct interpretation of the script. On-screen or printed text is more legible than handwriting and can reduce error and frustration of other health care providers.
3. **Security, privacy, and confidentiality:** It is easy to borrow patient records and photocopy them without discovery. Electronic medical record allows only an eligible person to view in each level of access. Data is safe because it is easy to make a back-up copy.
4. **Flexibility of data display and controllable data:** Data can be displayed in many different layouts. Data can be monitored as they are entered to eliminate errors, omissions, and duplication. However, structured data entry is required and accepted terminology has to be agreed by clinicians. The output format varies from printed document to e-mail. To find a specific data item, or to see whether it has ever been recorded, can be more convenient. Data analysis can be straightforward by linking data directly to statistical analysis software.
5. **Integration with other information resources:** Incorporation results from laboratory analysers, imaging devices, and clinical monitors is possible. Moreover, clinicians can access electronic reference material held locally on, through local area network (LAN), or through the internet.

6. Electronic data exchange and sharing care support: Data is only entered once and re-used.
7. Integrated decision support and guidance: This is to remind, warn, and advise clinicians on aspects of individual patient care. Computer-based tools for implementing such guidelines, and integrating them with medical records, provide a means for making high quality advice available in the routine clinical setting.

4.6.2. Potential Constraints in Building Electronic Medical Records

As stated the potential benefit of electronic medical record to a health care system is considerable, but in order to gain this benefit, there is a price to pay. There will be substantial effort, inconvenience, and compromise before the advantages accrue (Nikula, Elberg, & Svedberg 2000). Shortliffe (1999) indicated that there are at least four major issues that consistently constrain the efforts to build an effective medical record systems:

1. The need for standardised clinical terminology;
2. The challenges of data entry;
3. The concerns about data privacy, confidentiality, and security;
4. The difficulties associated with the integration of record systems with other information resource in the health care setting.

Other researchers also suggest that the implementation of systems can be problematic (Mohr et al. 1995), (Berg et al. 1998), (Nikula, Elberg, & Svedberg 2000).

1. The need for standard clinical terminology

Shortliffe (1999) stated that there is a need to standardise clinical terminology on the grounds of (1) the current clinical terminology is rich and comprises a variety of medical concepts; (2) the need for structured data entry to provide the clinical context for reliable audit, decision support, and data analysis. At present, there are many standard terminology systems including major ones such as International Classification of Diseases-9 (ICD-9), International Classification of Diseases-10 (ICD-10), SNOMED, Clinical Term, and UMLS. However, none is universally accepted or sufficiently comprehensive to meet all requirements for structured data entry. One of the systems that has been actively developed and provides some benefit is UMLS which in 1998 contained close to 500,000 biomedical concepts and over one million terms to describe

them (Shortliffe 1999). The standard clinical terminology in the CDSS in the diagnosis of CIFP may use two classifications: (1) the one which specific in facial pain diagnosis such as the Classification of International Headache Society and (2) the one for medical conditions.

2. The challenges of data entry

Structured data entry is well recognised as being essential to obtaining reliable data that is not only suitable for patient care but also for decision support and research. Unstructured data entry using paper-based forms has been shown to be unreliable (Luck, Peabody, Dresselhaus, Lee, & Glassman 2000). Hence, structured data entry will be more reliable than unstructured data entry using either paper-based or electronic medical records. However, the structured data entry does pose the problem of rigidity of terminology, and insufficiently expressive terminology. The optimal strategy for data entry depends on the complexity of the clinical findings in particular patients. In fact, it depends on the clinical domain whether it is general and large domain e.g. internal medicine or more specific and narrow domain e.g. orofacial pain. The user interface supporting data entry is of major interest for researchers since it is crucial in persuading users to take up the technology (Tang & Patel 1994). To assist the user, a menu-driven interface providing lists of possible items, or functional controls which offer freedom for users to choose relevant screens and tasks suitable for their need, are put into the interface design. Possible problems for menu-driven interfaces are too many screens and the lack of navigation. Another disadvantage is the inability to view the entire record. To solve this problem, one may need to have the option to summarise patient data for users, offer a navigation map, and display several levels of data simultaneously. The introduction of the hand-held computer or pen-based tablet shows promise in the clinical setting in term of time savings, and ease of use for data entry and also is mobile to carry and saves space (Hammer, Strain, & Friedberg 1995).

3. The concerns about data privacy, confidentiality, and security

There is great public concern about the potential for misuse of personal information by insurers and employers. In consequence, this has heightened concern about the confidentiality of medical records. Although it may be irrational to fear more for the privacy of electronic medical records than that for the paper medical record, in recent year concerns about protecting electronic medical records have increased. This raised anxiety among researchers

(Melton 1997). The study by Chadwick et al. (2000) has shown that internet access to patient medical records with ensured confidentiality is possible.

4. The difficulties of integrating the electronic medical record with other information resources.

Today new medical knowledge emerges at a rate that far exceeds the individual capacity to seek it out, read it and absorb it. It is well recognised that good practice of medicine needs an evidence-based approach. This demands access to information resources in the form of online guidelines, systematic reviews, or the primary clinical literature. The impact of acquired information on clinicians' decisions in patient care was clearly demonstrated in the studies of (Haynes et al. 1990) and (Lindberg et al. 1993). In the study of GRATEFUL MED¹ introduced in clinical settings, Haynes et al. (1990) found that clinicians reported use changed the course of patient care 47% of the time. Lindberg et al. (1993) studied the impact of MEDLINE to physicians' clinical problem solving. The analysis has shown that the most common impact of the information obtained was to develop an appropriated treatment plan (45%), followed by recognising or diagnosing a medical problem or condition (22%), implementing a treatment plan (14%), and maintaining an effective patient-physician relationship (10%). This study implies that online information retrieval is useful. If the computing technology can smoothly integrate the use of medical records and accessibility to online information, it will be useful for evidence-based clinical practice. Furthermore, with the introduction of networked systems within health care, there is an opportunity to integrate a wide variety of resources through single workstations. However, there are also the problems of; (1) reliability, and (2) information overload. Reliability may be dependent on systematic (evidence-based) reviews and meta-analyses e.g. Cochrane Collaboration, Bandolier, and National Institute for Clinical Excellence (NICE). Information overload may be a potential problem which has not been adequately explored.

4.6.3. Clinical Status of Electronic Medical Records

Although electronic medical records have been introduced and used since 1970s, the fully functional electronic medical record is only used on a small scale in clinical settings (van Ginneken & Moorman 1997). In the United

¹ GRATEFUL MED is a software tool that runs on a personal computer; it is distributed by the National Library of Medicine (NLM) to assist health care professionals to search MEDLINE and other databases at the NLM without the assistance of a professional search intermediary.

Kingdom by 1996, 96% of primary care clinicians work in a computerised practice (Royal College of General Practitioners 2000) but few hospitals implemented electronic medical records (Benson 2002). It is estimated that approximately 15% of these clinicians have dispensed with manual records and rely solely on electronic medical records (Royal College of General Practitioners 2000). The American Dental Association (ADA) Survey Centre has shown that there is a marked increase in the number of dentists who had a computer in their dental practice from 1984 to 1994 (Heiert 1997). This survey indicated that in 1984, only a small number of dentists (11%) had an office computer, but by 1994, two thirds of dentists (67%) reported having a computer in their practice; and most dentists used it for patient accounting and billing functions. The electronic medical record tends to be experimental in many specialised clinical settings such as obstetrics & gynaecology clinic, (Nielsen et al. 2000), neurology clinic (van der Meijden et al. 1999), and diabetes clinic (Gorman et al. 1996).

4.6.4. Review of Currently Available Electronic Medical Records

4.6.4.1. POMR-based Systems

This system is based on the Problem-Orientated Medical Record (POMR) concept of Weed (Weed 1971). The system offers the user a list of problems which are believed to represent a powerful method for organising, clarifying, and communicating clinical data and reasoning. However, optimal implementation of computer-based problem lists requires a structured problem vocabulary that is both meaningful to clinicians and computationally tractable. PROMIS (Problem Orientated Medical Record System) is one of the POMR. This system guides the clinician to enter the medical record, controls the problem list vocabulary, content and organisation of data and stores its information in sentences. Although it is extensively utilised at the Medical Centre Hospital of Vermont, the coercive nature of PROMIS is not generally acceptable among physicians.

4.6.4.2. Form Based Systems

The general nature of most computer-based medical record systems conceived in the 1970s lacked interactivity between users and systems. In addition, the

limitations imposed by the inherent technology hampered their widespread utilisation. To enter patient notes into the computers, the systems generally used the concept of encounter forms. During the consultation session, various paper-based encounter forms with partially structured fixed data items filled in by the physician. The patient observations were then entered into the computer by clerical staff. This system is useful for research purposes rather than for facilitating the patient consultation and it is labour intensive. The interface is not user friendly. Doctors are reluctant to use it in the consultation.

4.6.5. The Governmental Role in Supporting the Electronic Medical Records

Healthcare computing started flourishing in the United Kingdom, in the 1980s. In the past twenty years, the government via National Health Service (NHS) has introduced computerised projects like computers for general practices, clinical audit, nursing systems, hospital information support system (HISS), to support clinicians. However most of them have developed into management tools. The growth of information technology and various communication technologies has changed the face of medicine and care delivery procedures. Also a great demand for better organisation and access to medical information from patients, care providers, academia, and researchers, have all emphasised the need for driving the NHS to change the management of patients' medical records. In 1993, the Information Management Group (IMG) of the NHS Executive decided to support clinicians and sponsored a three year Electronic Patient Record Programme which started work in January 1994. Two hospitals were chosen as demonstrators i.e. Wirral and Burton NHS Hospital Trusts. From this study, three crucial factors promoting the successful implementation of the electronic medical records were: (1) a well integrated Hospital Information Support System (HISS), (2) the integration of the staff in the organisation, and (3) the integration of the human with the computer i.e. users feel comfortable to work with the computer (Dodd 2000).

The need for change to computerised medical records was evident when it was put in the 1998 NHS Information Technology strategy "Information for Health" (Burns 1998) and the "Electronic Record Development and Implementation Programme (ERDIP)" was launched. At the beginning, 4 successful

communities were chosen because of their potential to make rapid progress in implementing and testing the electronic health record concept. They were aimed to demonstrate that the patient information in the electronic health record can be shared across health and social service communities. A further 13 smaller sites were also recruited to look into certain particular issues including; interaction with the social services; links between primary and acute care; support for the implementation of National Service Frameworks (NSF) (e.g. cancer, mental health, coronary heart disease); support for out-of-hours and walk-in centre activities; telemedicine; and information content standards such as record headings and clinical terminology.

Electronic medical records have been viewed as two interrelating types i.e. (1) Electronic Patient Records (EPR) – a record of periodic care delivered mainly by one organisation such as a specialised unit, (2) Electronic Health Record (EHR) – a lifelong record of a patient's medical record and health i.e. information about a patient's contact with primary care and information from the EPR will also be included. The project target for achieving of level 3 of the development (see next section 4.6.5.1) i.e. clinical order (e.g. laboratory orders, imaging orders), results reporting, electronic prescribing, integrated care pathways; integrated decision support system for diagnosis/treatment and administrative data; and 24 hours access to EHR is aimed at 2005 and a full electronic records service implemented nationally by 2008.

4.6.5.1. The Levels of an Electronic Health Record

To achieve the full goal of an Electronic Health Record, the minimum criteria of different level of development have been set up. (Figure 4-4)

Level 6	Advanced multi-media and telematics Level 5 <i>plus</i> telemedicine, other multi-media applications (eg, picture archiving and communications systems)
Level 5	Specialty specific support Level 4 <i>plus</i> special clinical modules, document imaging
Level 4	Clinical knowledge and decision support Level 3 <i>plus</i> electronic access to knowledge bases, embedded guidelines, rules, electronic alerts, expert system support
Level 3	Clinical activity support Level 2 <i>plus</i> electronic clinical orders, results reporting, prescribing, multi-professional care pathways
Level 2	Integrated clinical diagnosis and treatment support Level 1 <i>plus</i> integrated master patient index, departmental systems
Level 1	Clinical administrative data Patient administration and independent departmental systems

Figure 4-4: The levels of an Electronic Health Record (Burns 1998)

Level 1 and 2 focuses on the computerised patient administration system captured to a department at the level 1 but with interdepartmental integration at level 2. The computerised medical record is expected to be set up at level 3 “Clinical Activity Support” as part of the Integrated Care Pathway Service Phase 1 project. This level aims to support clinical notes, shared care between departments and also facilitate online laboratory/radiology orders, result/reporting viewing, prescribing, and referral/discharge letters. Speciality Units such as Pain, Diabetes, Coronary Heart Diseases etc., are expected to take part in the integrated care pathway project. Level 4 concentrates on clinical knowledge and the decision support system to be implemented. Clinical knowledge includes guidelines and protocols for diagnosis, laboratory/radiology/pathology ordering, viewing evidence based information (e.g. medical references, drug interaction databases). Decision support systems include interactive knowledge enabled laboratory order entry, alerting and

surveillance. The specialty units are focused in level 5. This includes all functions in level 3 and 4 with emphasis on their specific functions and integration with other systems in EPR. Advanced multi-media (e.g. video&speech, clinical images, ECG) and Telemedicine & video-conferencing are focused in level 6.

4.6.5.2. The National Electronic Health Record Architecture

There is no agreement yet on the Electronic Health Record architecture. The evidence from current health organisations suggests that a two-level structure is required i.e. (1) local level and (2) national level (NHS Information Authority 2002). Local level of Electronic Health Record includes the local health organisation, the old health authority, and the Strategic Health Authority (StHA). The local health organisation embraces local patient record systems in hospitals, community Trusts, GP practices, NHS Direct, and client record systems found in Social Service departments. The old health authority is defined as the one that existed in England up to March 2002 serving on average some of 600,000 of the population whereas a Strategic Health Authority (StHA) is one that has on average 1.5 million patients. At the national level, the Health Records Infrastructure (HRI) will provide a point of focus for raising and dealing with confidentiality and information sharing in the NHS i.e. it allows the authorised NHS users to see the potentially many health records of their patients from a variety of sources through one interface and also allows patients to see and maintain their health records.

The Electronic Health Record provides an Integrated Care Records Service (ICRS) for the whole country. The following diagram (Figure 4-5) illustrates the architecture of Integrated Care Record Services to support the provision of care across the whole health community including local and national services. This shows, in the upper part, the services provided at the local level and in the lower part, the service provided at the national level. These elements need to be integrated. The linked arrows are where the standard needs to be applied to enable this. These links are needed within local services, between health communities, between local and national services.

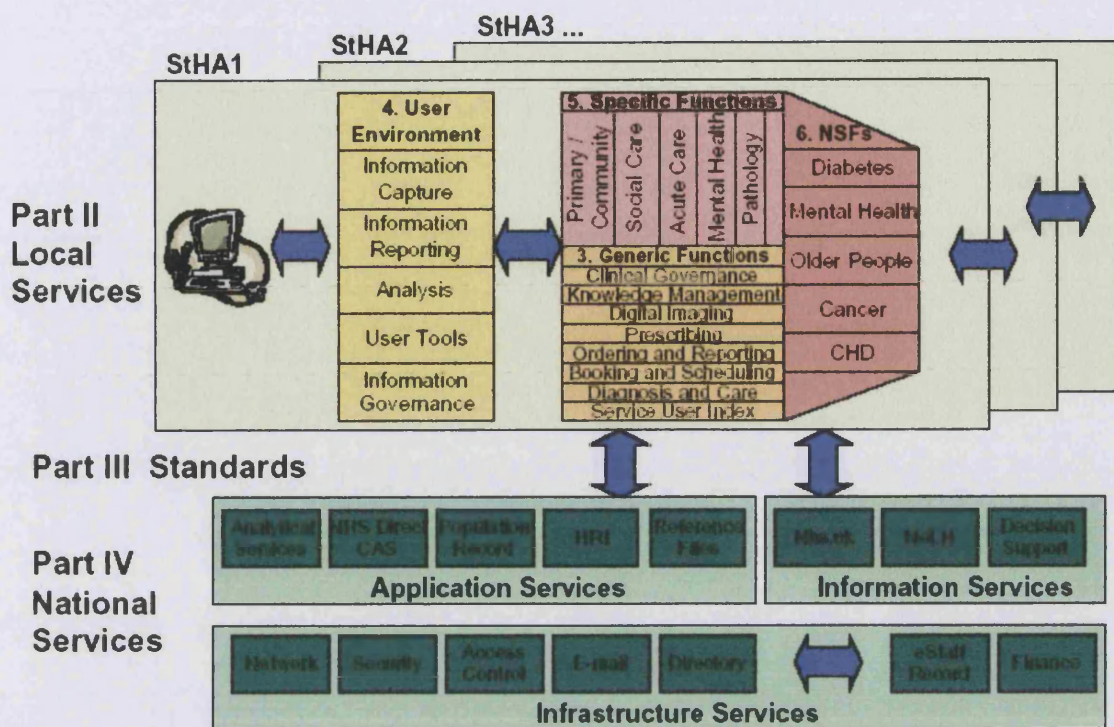


Figure 4-5: The architecture of Integrated Care Services system (Department of Health 2002)

At the national services, a set of infrastructure services were constructed to support both national and local implementation activities. It comprises 3 main services i.e. (1) infrastructure services such as network, security, access control, E-mail, directory, staff record, and finance, (2) application services include operational areas such as the development on the Health Records Infrastructure (HRI), the National Patient Records Analysis Service (NPRAS), the National Strategic Tracing Service (NSTS), and NHS Direct, and (3) Information services online via the "nhs.uk" web site which is the official gateway to access the NHS organisations and clinical e-learning such as the National Electronic Library Service for Health (<http://www.nelh.nhs.uk>), guidelines found in prodigy web site (<http://www.prodigy.nhs.uk>) or the National Institute of Clinical Excellence (NICE) web site (<http://www.nice.org.uk>), drugs information of the British National Formulary (BNF) found in e-BNF web site (<http://www.bnf.org>). The national infrastructure integrated to local services in NHS hospitals, communities bases, social services, and specialty bases. National Service Frameworks (NSFs) are being developed to deliver specific treatment areas of health. Dentistry and its subspecialty disciplines have not yet been specified in the integrated care service.

4.6.5.3. Suggestions for the Electronic Medical Record Using in the Facial Pain Clinic

The concepts of the Electronic Patient Record and the Electronic Health Record introduce the important features of co-operation, shared-care, and a national approach. Therefore the services will need to conform to national standards. National standards are critical to enable the exchange of information with access to health records across the whole country. The following suggestions are fundamental for the implementation of an Electronic Health Record:

- A computerised medical record should be developed to collect patient history data, and examination data. The structured medical record is preferable to serve the purpose of data exchange with the availability of free text entry to serve clarification of some clinical detail.
- Data structure should be a relational database system which is available in many softwares.
- Clinical terminology and classification should be SNOMED CT which is now being implemented in the computerised medical records in the NHS.
- Clinical communication should be HL7 version 3 for administrative data and DICOM for imaging which are now being implemented in the NHS.
- To enable the tracking of the origin of data, the XML schema is recommended and it is being implemented in the NHS.

4.7. Electronic Eastman Pain Proforma (EEPP)

This will focus on the development of a computerised FPP which is characteristic of an electronic medical record. The clinical data record in working practice i.e. Facial pain clinic at the Eastman Dental Institute is discussed. The interface, database design, and behaviour of the computerised form of the FPP are described.

4.7.1. Design Considerations of the EEPP

The design and development of a valuable and practical electronic record require considerable attention and efforts from both developers and the potential users. The key is to continuously monitor and test the impact of the designed system on the care delivery as the system is being developed.

Potential users are asked to evaluate the system and its functionality at various stages of the development. The main reason why we introduce the EEPP is to explore the possibility of orofacial computerised medical records. This is fundamental for the further development of the logical rule base of the decision support system for the diagnosis of CFP. The EEPP receives the clinical data input which will integrate with the algorithm and present the output to the users as a critique, suggestion, and differential diagnosis. The subsequent potential benefits of the EEPP are;

- To build a structured patient entry record
- To encourage the clinician to take a thorough history of pain
- Reduce the amount of paper-based medical records and facilitate the management of records such as storage and the retrieval of data
- Research
- Educational tool
- Clinical audit

4.7.1.1. Defining Health Care Needs

As stated by Dick and Steen (1997), the quality of a patient record system depends on its ability to meet a needs and requirements of those who use it. The steps suggested by the continuous quality improvement model to develop the improvement process of a patient record system are

1. identify the users
2. understand their requirements
3. translate those requirements into functional characteristics of the system
4. design system capable of supplying these functional characteristics
5. implement the design
6. prove the value of the system
7. stabilise or further improve the system depending on the results of ongoing evaluation

The first three steps are adapted to use.

• Identify the EEPP Users

The users of the EEPP will be those who enter, verify, correct, analyse, or obtain information from the record, either directly or through an intermediary. The users provide, manage, review, or reimburse patient care services; conduct clinical or health services research; educate health care professionals or patients; develop or regulate health care technologies; accredit health care professionals or provider institutions; and make health care policy decisions. All of these users are potential customers of the EEPP, and their needs should be considered. The primary users are practitioners (dentists, physicians, nurses and other health care professionals), patients, administrators, third party payers, and researchers. Table 4-2 lists examples of potential users of the EEPP.

Table 4-2: Potential individual users of the Electronic Eastman Pain Proforma modified from (Dick & Steen 1997).

Patient Care Delivery (Providers)
Dentists
Physicians
Clinical psychologists
Dental nurses
Dental hygienists
Physical therapist
Social workers
Patient Care Delivery (Consumers)
Patients
Families
Patient Care Management and Support
Administration
Quality assurance and managers
Unit clerks
Others
Government policy makers and legislators
Lawyers
Health care researchers and clinical investigators

• Users needs

The primary use of patient records is for patient care. The others extend beyond direct patient care. Tables 4-3 and 4-4 list examples of primary uses and secondary uses of the EEPP.

Table 4-3: Primary uses of the EEPP modified from (Dick & Steen 1997).

Patient Care Delivery (Provider)
Support decision making for the diagnosis and treatment of patients
To foster continuity of care i.e. serve as communication tool
Describe disease and causes i.e. support diagnostic work
Assess and manage risk for individual patients
Remind clinicians
Document services provided

Patient Care Management

To characterise the use of services
 Provide the basis for utilisation review
 Perform quality assurance

Patient Care Support

Assess workload

Table 4-4: Secondary uses of the EEPP modified from (Dick & Steen 1997).**Education**

Document health care professional experience
 Prepare conferences and presentations
 Teach health care professions students

Research

Conduct clinical research
 Assess technology
 Study patient outcomes
 Study effectiveness and cost-effectiveness of patient care
 Identify population at risk
 Develop registries and databases

Regulation

Serve as evidence litigation
 Assess compliance with standards of care
 Accredite professionals and hospitals

Policy

Allocate resources
 Conduct strategic planning

Although the user requirement identification has not been formally done specific to our group of users, we have analysed the requirement in general from previous literature. There are some areas which are needed to be discussed.

4.7.1.2. System Requirement

The 'users' needs are translated into system requirements. This section will focus on these system requirements.

4.7.1.2.1. Decision Making Support

One of the functions of the EEPP is to support decision making for the differential diagnosis of CIFP. In general, computer-based patient record systems can support practitioners by providing at least five kinds of tools that are not available with paper records. These tools include mechanism for focusing attention, for patient-specific consultation, for information management, for data analysis, and for implementing quality assurance and cost management policy (Dick & Steen 1997). A specific, automated record system can help practitioners recognise out of a range values or dangerous

trends, recall available options, and make better clinical decisions. Human memory is imperfect, especially when big data involved with the required memory. The computer can be relied on to remember large data items accurately and can check routinely whether the practitioner has forgotten any standard items relevant to the diagnosis or treatment of particular problem. For example; the computer system will alarm users when drugs which are not suitable for a patient are prescribed.

4.7.1.2.2. Data Quality

The quality of data depends on its legibility, accuracy, completeness, and meaning. The accuracy of the electronic medical record can be enhanced by data-entry screens and logical rules that flag or block inappropriate entries for particular data fields. The electronic medical record can reduce the potential source of errors by reduce the need for intermediate entries (i.e. for transcription or using clerical entry) but allow clinicians to enter data directly into the electronic medical record. The completeness of patient records depends in part on agreement among users about uniform core data elements. Without such uniformity, what one patient record user views as complete data may be considered incomplete by another. Although the consensus among clinicians for uniform data is difficult to gain, this must be justified. The completeness of records depends in part on the time it takes to add new information to the record. Accuracy and completeness are required when clinical data are used in decision-making in the decision support system. As mentioned previously, the need to conform with the national Electronic Health Record has to be considered.

4.7.1.2.3. The User Interface

A crucial element for user acceptability is a user interface. It should be easy to use and can be enhanced by increasing the extent to which the system can respond to the user's knowledge. The lay-out of the data entry and the data presentation forms increase the transparency of the electronic medical record for users. Predefined response categories were allocated wherever possible. Users should be able to display information at different levels of detail. All users should be able to retrieve most queries without the intervention of a programmer.

4.7.1.2.4. Security

There are two security requirements. Firstly, the patient and provider privacy must be protected. Secondly, the data and software must be safeguarded against tampering and unintentional destruction.

4.7.1.2.5. Connectivity

Connectivity denotes the potential of the record or record system to establish links to interact effectively with any sort of provider or database that may improve the care of the patient.

4.7.2. Analysis of the Working Place

4.7.2.1. Facial Pain Clinic: An Overview

This study was performed in the Facial Pain Clinic of a university hospital. The Facial Pain Clinic is run under the care of the Department of Oral and Maxillofacial Surgery, Eastman Dental Institute and Hospital, University College London. This is a tertiary care unit which accepts patients from general medical practitioners (GMP), general dental practitioners (GDP), and other specialists. Approximately 70 patients are referred to this clinic each month. The professionals who manage the patients consist of orofacial pain specialists, a psychiatrist, a clinical psychologist, a specialist nurse, and a dental assistant. Each of these contributes with his/her specific knowledge and background to the treatment and care process. The team meets once a week to discuss patients and their treatment plan.

4.7.2.2. Patient's Route

Referral letters are sent by the GMP/GDP to the Facial Pain Clinic. The clinic sends an appointment to the patient at which the patient visits the clinic to register, and see the clinician. The patient record is created at the first visit, and a full history and examination is taken by a clinician. The diagnosis is made and treatment prescribed. Review appointments are given in appropriate cases. A summary letter is sent to the GDP and GMP about the patient. The patient's route is depicted in the Figure 4-6.

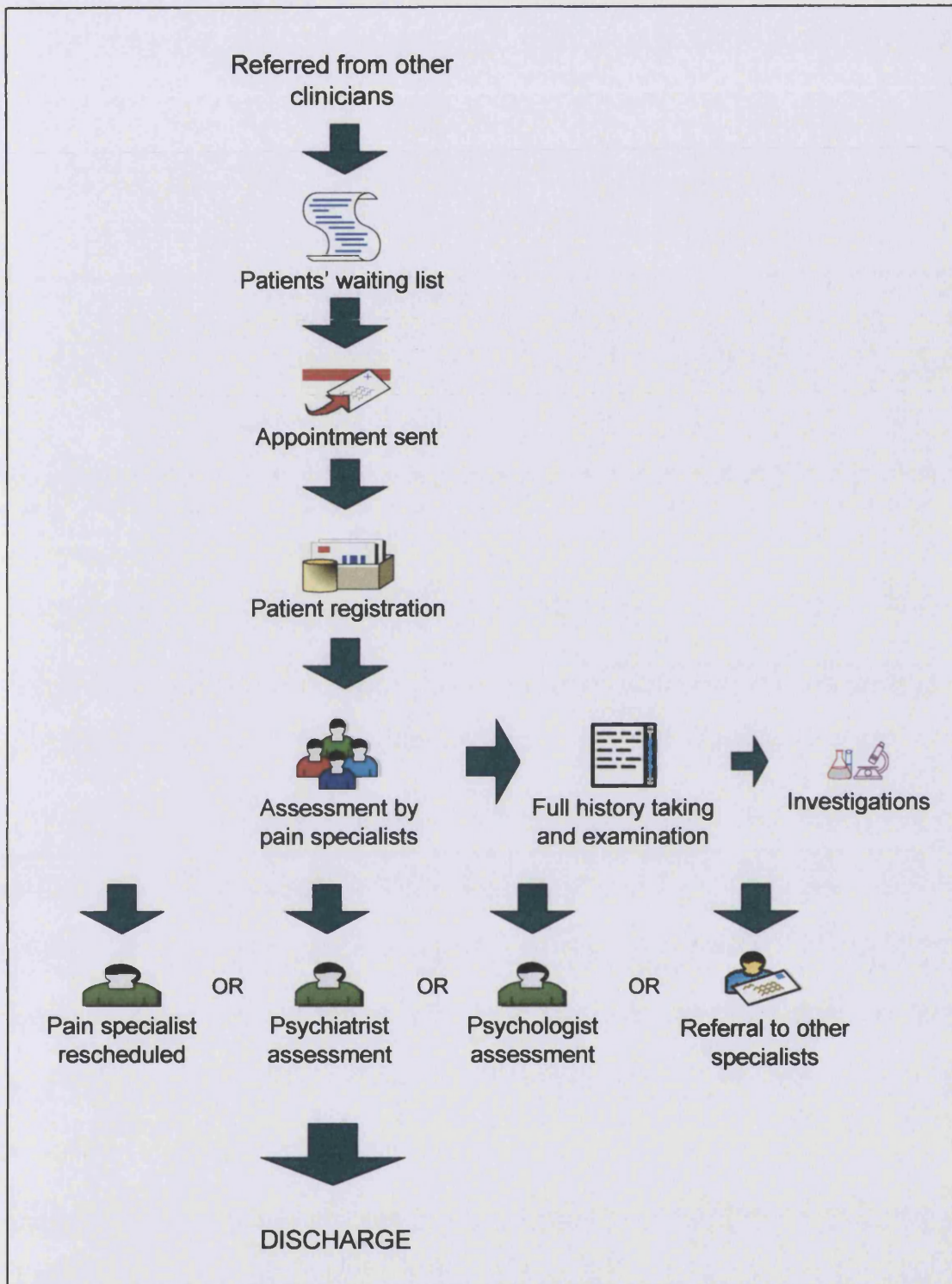


Figure 4-6: Patients' Route to the Facial Pain Clinic

4.7.2.3. Paper Work

Each discipline in the hospital has a separate clinical record. After finishing each visit, the medical record is used by a secretary for preparing a letter to communicate with other corresponding practitioners. Then, it is returned to medical record department for storage and future use. One characteristic of the

paper records is that they are organised by the source clinician, using a speciality colour code. Different specialities use different colours of note paper. They also have their own clinical abbreviations, and handwriting. Laboratory results arrive by internal mail from the laboratory, and also can be viewed via a network computer. The responsible practitioner initials these results and they are subsequently added to the medical record. Narrative, authorised reports of other diagnostic tests arrive – in general – days or sometimes weeks afterwards, and upon arrival they are added to the medical record. If a patient is referred to another department, that department will need the records.

4.7.3. Electronic Eastman Pain Proforma (EEPP) Development

Architectural models are developed to reflect the underlying aims of a patient-centred, and clinically usable electronic medical record system. The functional architecture of the EEPP may include:

- **Access Control Application:** This deals with the security of access.
- **Record Driven Application:** This is based on computerised medical records and direct patient interaction with the records stored in the database.
- **Intelligent Application:** This consists of a clinical decision support system to aid the clinical decision making process and differential diagnosis.
- **External Connection:** This provides a connection to other databases and remote resource knowledge via a Universal Resource Locator (URL).

The EEPP physical architecture consists of table database at the backend and forms and Visual Basic for Application (VBA) programming code at the front-end.

4.7.4 Database Modelling of EEPP

Database modelling is the key to facilitate standardised and intelligent data capture. The simple and easiest way to store data is an arrangement in rows and columns in a table. Many spreadsheets such as Microsoft Excel can handle tables by arranging it in a single table (or a flat file). The major disadvantage of this arrangement in a single table is the lack of the ability to make cross-

references between files. Also the other disadvantages with this approach are redundant data, inconsistent data, inflexibility to modify or change the data, creating fields with no value which waste storage space, and the lack of inherent control of data quality. Therefore, the database structure of the EEPP is designed to be a Relational Database Management System (RDMS) which can solve those problems. In a relational database, the data values held are stored in tables arranged in rows and columns like a spreadsheet. These tables are related to each other using relationships that can be used for cross-references. This model has two important key concepts; (1) the entity-relationship (E-R) representation of data elements and (2) data integrity rules which provide links between the various data elements within tables. The entity-relationship represents how the items about which data has to be stored fit together. An entity is anything of significance about which information needs to be held. Examples are a staff member, a patient, a visit to clinic, and history. Data integrity is a set of rules by which the database system and its programmers can ensure that data is valid and conforms to a designed structure. There are two important integrity rules, which are constraints or restrictions that apply to all records of the database. The principal rules for the relational data model are; entity integrity and referential integrity.

Commercial systems based on the relational model started to appear in the late 1970s and early 1980s. Examples are Filemaker Pro, MySQL, Oracle, and Microsoft Access. Microsoft Access 97 is a RDMS software designed to use with microcomputer environment and was employed for the EEPP. The reasons are: (1) It is compatible with Microsoft office software suit (e.g. Microsoft word and Excel) which widely used in personal computers; (2) It can cope with small to medium database (i.e. thousands of records); (3) It is easy to use without the need of extensive programming skill; (4) It is not expensive.

4.7.4.1. Entity Integrity

The first integrity rule applies to the records in the tables. A table has one column or a group of columns to uniquely identify each row – this is called the primary key of the table. For example, an arbitrary number called “patient identity” is designed to uniquely identify a patient.

4.7.4.2. Referential Integrity

Referential integrity applies to the relationships defined among tables. It exists to validate the references that one table makes to another. When relationship between tables is represented in a relational database, a table may contain columns that link to the primary key of another table. This is called a foreign key.

4.7.4.3. Normalisation

This is an important concept in the relational model that reduces the redundancy of fields in tables and enhances functionality in data retrieval and storage. Each table is “normalised” to satisfy certain properties or constraints between various table entities and columns within the table. Normalisation encourages breaking complex tables into multiple simple tables, thus eliminates redundant data fields. Each group of data that logically belongs together is contained within its own table. However, where there are too many tables and scattered data, there is difficulty in query design and reduced data access time.

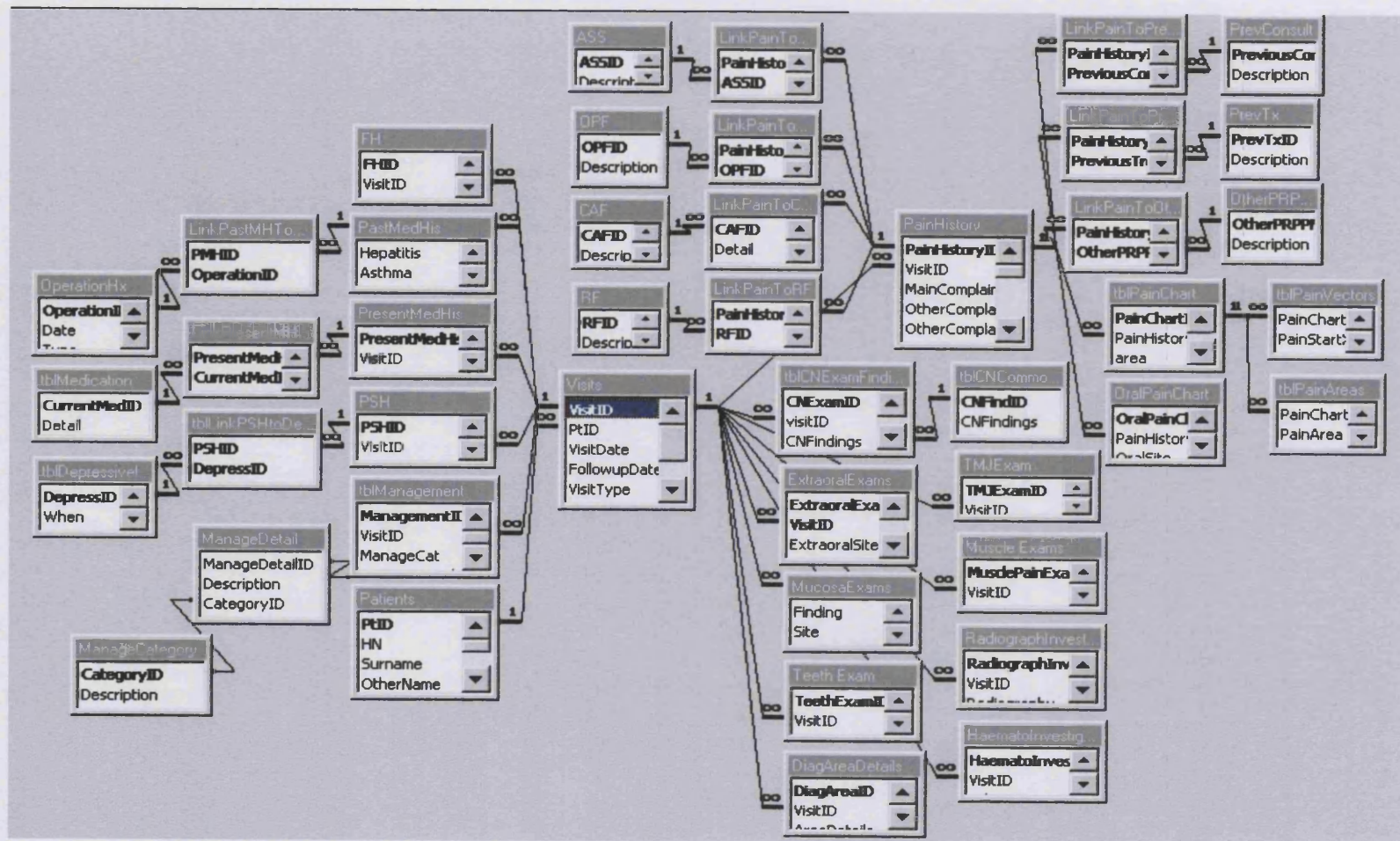


Figure 4-7: The database model of the EEPP. It contains tables linking one another using a special relationship represented by line such as “one (1) to many (∞)” relationship.

The enhanced database scheme helps the EEPP application functions to respond to user queries and intelligent data capture from history data taking. The various tables and relationships are related in a patient-specific and user-specific manner reflecting the context relevance and interrelationships of data contained within them.

Figure 4-7 illustrates the tables and their relationship in the EEPP database. Most of the relationship between tables are one-to-many relationship denoted as “1” on the one side and “∞” on the many side. For example the relationship of table “patient” and “visit” is one-to-many relationship means that a patient can have many visits to the facial pain clinic. The visit table is important for supporting structured data collection, and interface design. It also holds the key to clinical data organisation for each patient. The history table entities consist of pain history, past medical history, present medical history, family history, and psychosocial history which are structured to store patient history information. The examination entities table include the cranial nerve examination, teeth examination, TMJ examination, muscle examination, and mucosal examination. Other group of tables includes radiographic findings, haematology findings, management, diagnosis, aggravating factors, relieving factors, associated factors, pain areas, medication, and hospitalisation details.

4.7.5. EEPP - System Description and Functionality Analysis

In this section, we discuss the various user interface features including functional, operational and interactivity of the EEPP system. The user interface dynamically links and queries the appropriate tables to obtain the required patient information and the resulting information is properly structured, formatted and served back to the interface. Each interface is designed to provide a simplified representation of and access to vital clinical information in a natural context to the user.

4.7.5.1. User Interaction

Data entry is mostly via a digital pen, applied directly on the computer screen (see Figure 4-8). This is comparable to the clinician’s paper-based medical record. This graphic user interface enhances the ease of user interaction with computer. The user does not need to remember specialised set of keywords

related to data interaction events, and it allows a rapid and intuitive machine-operator interaction by applying the programming using Visual Basic for Application (VBA) code.

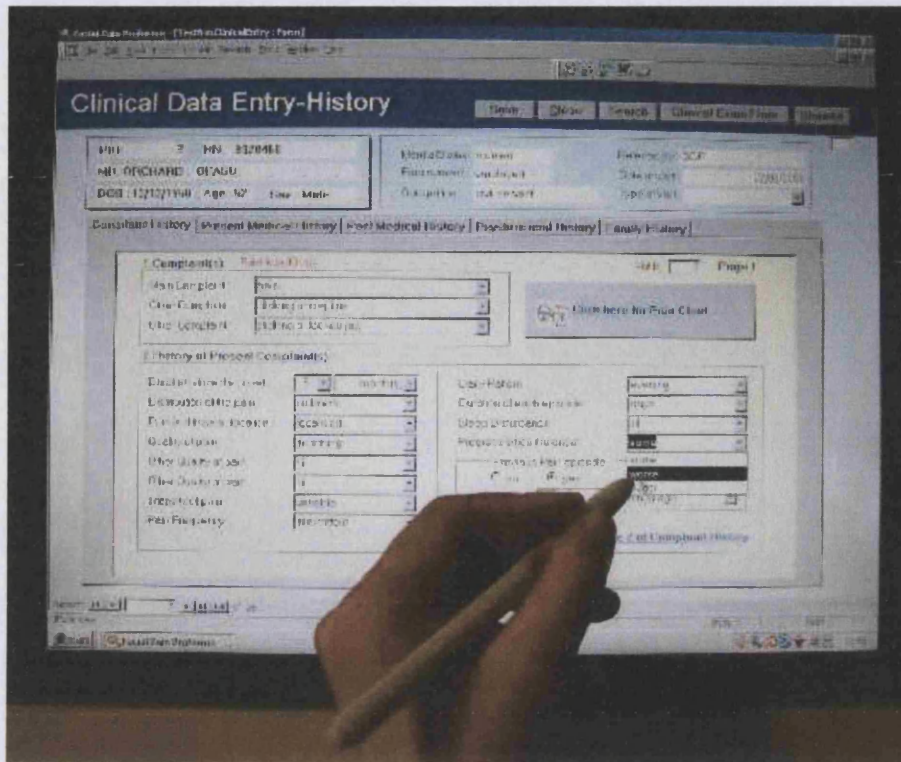


Figure 4-8: Data entry is via a digital pen

4.7.5.2. Main Switch Board Menu

Figure 4-9 is the first interface presented to the user on successful authentication of the user's login details. From this menu the user can choose to add a new patient, view the list of patients in the database (Figure 4-10), or view the clinical information of an old patient in this database.

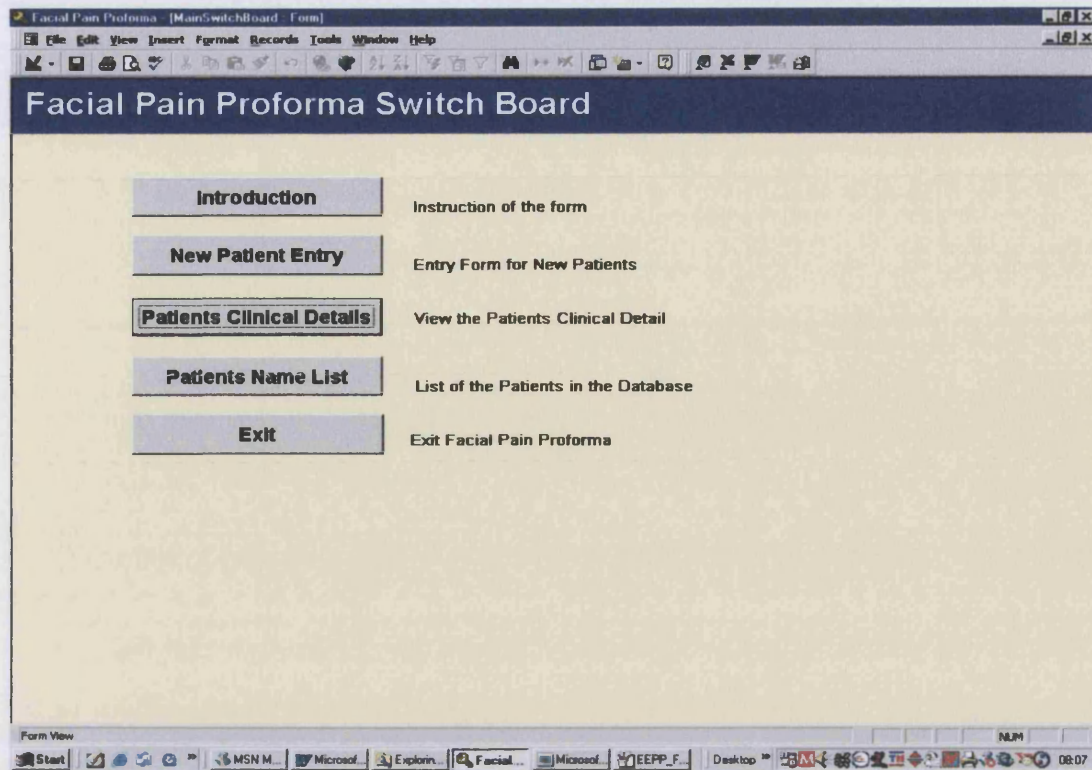


Figure 4-9: The main switch board menu of the EEPP

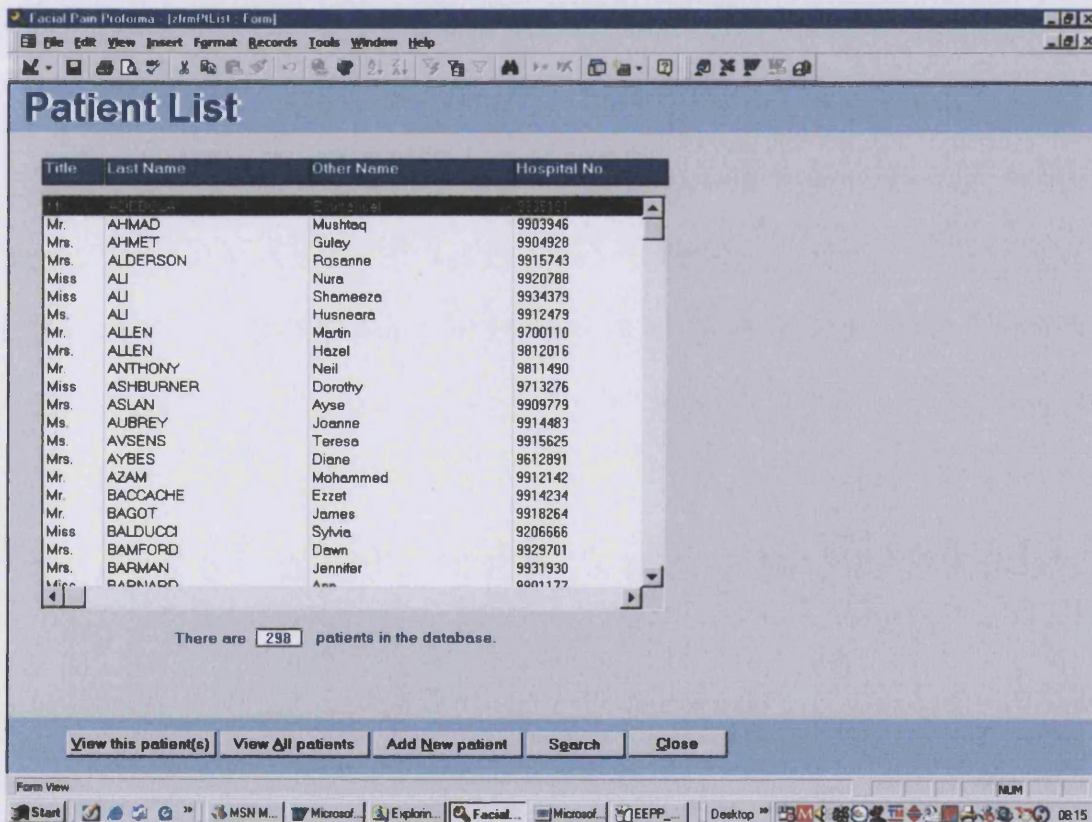


Figure 4-10: Patient list screen to view the patients in the database

4.7.5.3. Patient Main Clinical Data Entry

This screen is designed for entering the clinical data for a new patient. This form is designed to assist navigation through the source-oriented structured of medical record. There are 3 main screens including “Patient Data Entry”, “History Data Entry”, and “Examination Data Entry”. In Figure 4-11 is shown the validation in “Patient Data Entry”. This function will alert the user when there is unfilled crucial data such as patient’s hospital number, first name and surname. This is to ensure good quality of data. The VBA code handling this validation is shown in Figure 4-12. When the user finishes filling the data in the “Patent Data Entry”, those essential demographic data are transferred to the “History Data Entry”. This handles by another VBA code as shown in Figure 4-13. Figure 4-14 shows the drawing design of the “History Data Entry” architecture. The upper part is the area of patient demographic data and the lower locates a group of “tab controls” for the histories. The finished “History Data Entry” and “Examination Data Entry” are shown in Figures 4-15 and 4-16. The diagnosis and treatment data entry screen (Figure 4-17) can be accessed from “Examination Data Entry” screen by clicking on the last tab control. In fact, the structure of the “Examination Data Entry” is the same as the “History Data Entry”. It was separated for the purposes of better layout and focus and reduction of information.

Patient Data Entry

Patient ID: 373
 Hospital Number:
 Last Name: GRIGOROVA
 First Name: Poza
 Date of Birth:
 Age (years):
 Referred by:
 Ethnic:
 Country of Origin:
 Demographic Details:
 Marital Status:
 single
 partner
 married
 separated
 divorced
 widowed
 Employment:
 student
 house wife
 employed
 unemployed
 retired
 Occupation (if unemployed or retired state last occupation):
 Do you like your job? ☐ yes ☐ no
 If not, state reason:
 Save Clinical Data Entry Show All Patients Add New Patient Switch Board Undo Close

Record: 1 of 1
 Form View
 Start MSN Micro Explor Faci... Micro... EEP... Word... Desktop 08:30

Figure 4-11: The “Patient Data Entry” screen. The alert message is warning about the blank hospital number field.

```

Form: frmPatientEntry - Class Module
cmdAddCliDetails Click
Option Compare Database
Option Explicit

Private Sub cmdAddCliDetails_Click()
    'Test whether there is PtID, HN, and surname before save.

    If IsNothing(Me!PtID) Then
        MsgBox " You must type in a Patient pain clinic no., HN.,and Name before opening clinical data ent
vbCritical, "Patient Data Entry"
        Me.PtID.SetFocus
        Exit Sub
    End If
    If IsNothing(Me!HN) Then
        MsgBox " You must type in HN., Patient pain clinic no., and Name before opening clinical data ent
vbCritical, "Patient Data Entry"
        Me.HN.SetFocus
        Exit Sub
    End If
    If IsNothing(Me!Surname) Then
        MsgBox " You must type in Patient's name,HN., and Patient pain clinic no. before opening clinical
vbCritical, "Patient Data Entry"
        Me.Surname.SetFocus
        Exit Sub
    End If

    Dim frm As Form
    Dim strCriteria As String

```

Figure 4-12: The VBA code for data validation behind the “Patient Data Entry” screen.

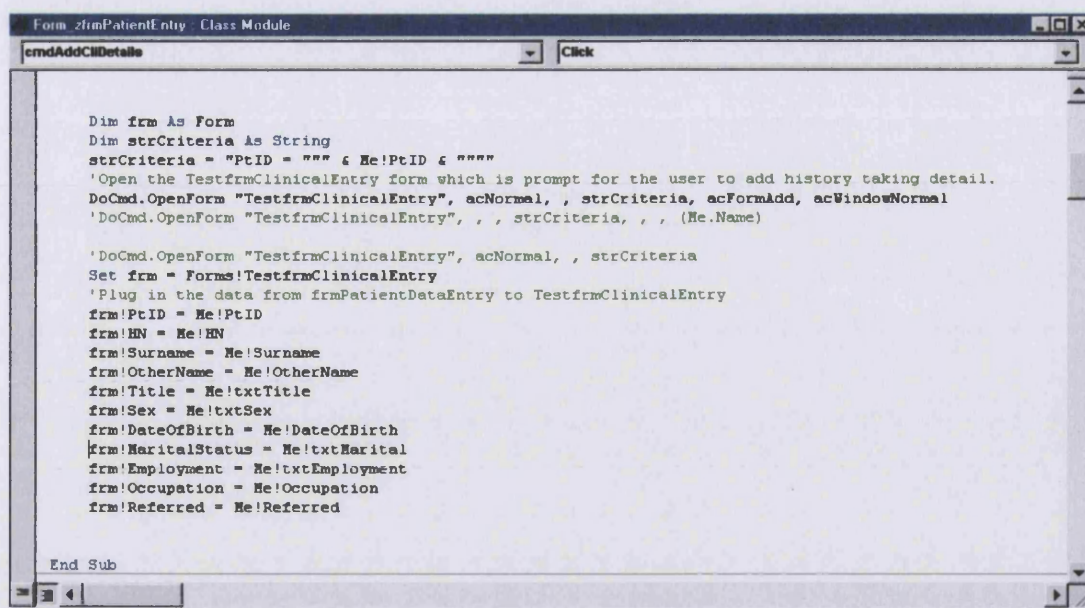


Figure 4-13: The VBA code for transferring demographic data in the “Patient Data Entry” screen to the “History Data Entry” screen.

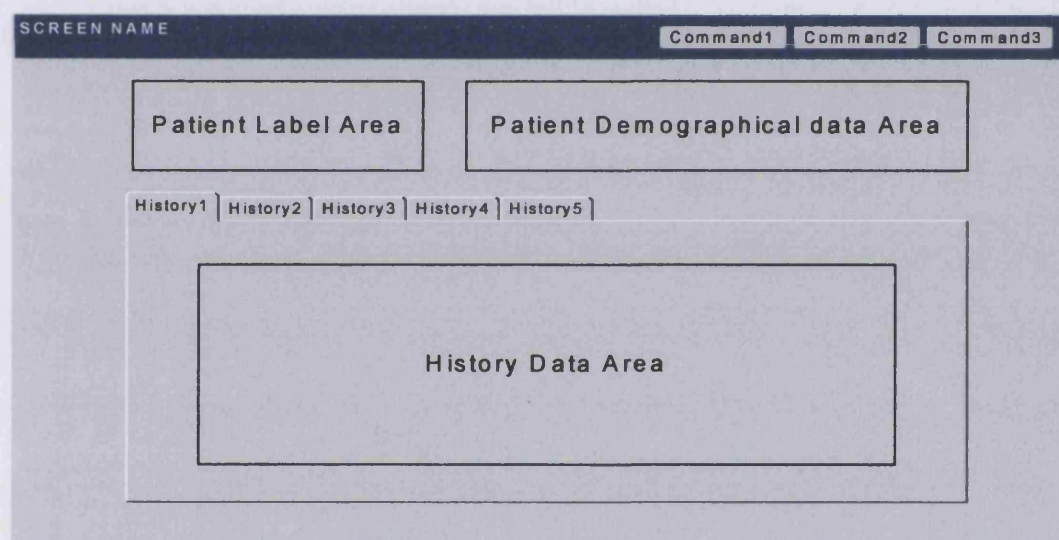


Figure 4-14: The designed drawing of “History Data Entry” screen consists of areas including screen name, command area (e.g. commands1, 2, and 3), patient label area (e.g. name, HN., DOB, age, gender), patient demographic area (marital status, employment, visit date), history data area which located on the tab controls can be viewed as required by click on each tab.

Facial Pain Proforma - [TestFormMainEntry - Form]

File Edit View Insert Format Records Tools Window Help

History Data Entry Save Close Search History Data Entry Exam Data Entry ShowAll

VisitID: 118 HN: 9926372 PID: 137
 MS. GRIGOROVA, ROZA
 DOB: 21/07/50 Age: 50 Sex: Female

MaritalStatus: divorced Referred by: GMP
 Employment: unemployed Date of visit: 19/03/01
 Occupation: actress in puppet theatre Type of visit: new

Complaint History | Present Medical History | Past Medical History | Psychosocial History | Family History

1. Complaint(s): Pain History ID: 157 VisitID: 118 Page 1

Main Complaint: pain
 Other Complaint: limited mouth opening Click "Save" after finish complaint
 Other Complaint: nil
 Other Complaint: nil

Click here for Face Chart
 Click here for Oral Chart

2. History of Present Complaint(s): Con. To Month

Duration since the onset: 5 month(s)
 Distribution of the pain: unilateral
 Pain is diffuse or localise: localised
 Quality of pain: dull ache
 Other Quality of pain: nil
 Other Quality of pain: nil
 Other Quality of pain: nil
 Intensity of pain: variable

Pain Frequency: intermittent
 Frequency of episode: daily
 Duration of each episode: hours
 Daily Pattern: anytime of the day
 Other Daily Pattern: nil
 Sleep Disturbance: prevent
 Progress since the onset: same

Go to Page 2 ...

Record: 64 of 298

Form View

Start MSN Mess... Microsoft... Exploring... Facial P... Microsoft P... Desktop 07:58

Figure 4-15: The “History Data Entry” screen. All the histories are visible to the user to facilitate navigation. All command buttons are grouped in the header of the form.

Facial Pain Proforma - [TestFormMainEntry - Form]

File Edit View Insert Format Records Tools Window Help

Examination Data Entry Save Close Search History Data Entry Exam Data Entry ShowAll

VisitID: 118 HN: 9926372 PID: 137
 MS. GRIGOROVA, ROZA
 DOB: 21/07/50 Age: 53 Sex: Female

MaritalStatus: divorced Referred by: GMP
 Employment: unemployed Date of visit: 19/03/01
 Occupation: actress in puppet theatre Type of visit: new

Cranial Nerve Examination | Extra-IntraOral Examination | Radiographic and Lab Investigation | Summary of the Patient

Click on the below button to select examination:

Extraoral TMJ Muscle Teeth Mucosa

Teeth Examination

Identified the tooth which found abnormality: all remaining teeth

Specified the abnormality(s):

☒ nil ☐ cavity ☐ pocket formation ☐ sensitive to hot
☐ attrition ☐ dental caries ☐ mobility ☐ sensitive to exploration
☐ filling ☐ clinical crown fracture ☐ exposed pulp ☐ rebound pain
☐ restoration ☐ fracture line on exploration ☐ tenderness to percussion ☐ negative EPT
☐ recent restoration / endodontic ☐ gingival recession ☐ sensitive to cold ☐ hyperocclusion / over instrument

Additional details of teeth examination:
 25 periodontitis / upper long span anterior bridge

Record: 1 of 1

Record: 64 of 298

Form View

Start MSN M... Microsoft... Explor... Facial... Microsoft... EEPP... Desktop 08:04

Figure 4-16: The “Examination Data Entry” screen. This screen can be accessed from the “History Data Entry” shown in Figure 4-14.

Examination Data Entry [Save] [Close] [Search] [History Data Entry] [Exam Data Entry] [ShowAll]

VisitID: 118 HN: 9926372 PID: 137
 MS. GRIGOROVA, ROZA
 DOB: 21/07/50 Age: 53 Sex: Female

MaritalStatus: divorced Referred by: GMP
 Employment: unemployed Date of visit: 19/03/01
 Occupation: actress in puppet theatre Type of visit: new

Cranial Nerve Examination | Extra-IntraOral Examination | Radiographic and Lab Investigation | **Summary of the Patient**

Diagnosis:
 Facial Arthromyalgia (FAM)
 Record: 1 of 1

Clinician:
 Premthip Chalidapongse [Click to add New Clinician]
 F/U Date: [Click for Calendar]

Treatment Type	Treatment Details	Dose (if any)	Frequency (if any)	134	118
reassurance and discharge	explanatory/pain handout	n/a	n/a		

Record: 1 of 1

Record: 64 of 298

Form View

Start [Icons] Desktop 06:10

Figure 4-17: The summary of diagnosis and treatment screen is located on the last tab. This page is designed for data entry of the summary diagnosis, treatment, and the clinician who clerked the patient.

4.7.5.4. Face Graphic

This screen is designed to assist the user to enter the area of complaint, it is easy to view and locate the problem. The screen is a pop up form and can be accessed when working with the complaint history taking.

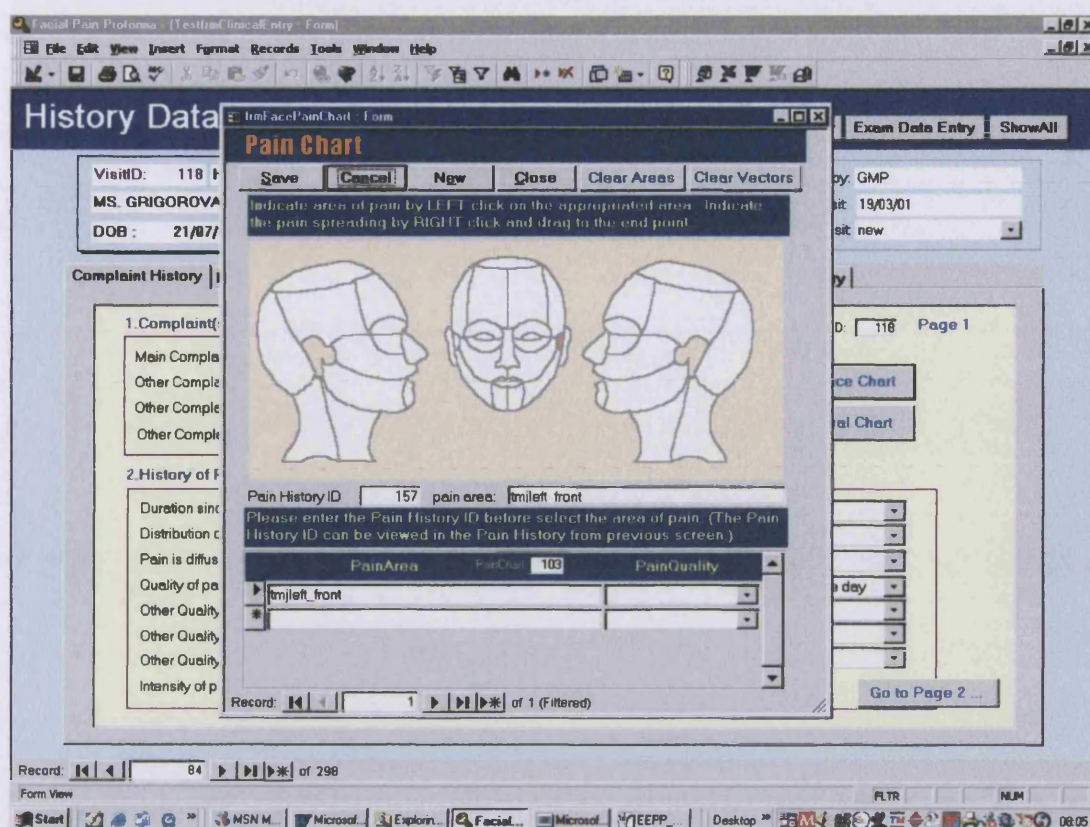


Figure 4-18: The “Face Graphic” screen which can be accessed on pain history data tab. When the area is selected the colour changed and the name of area appeared on screen to notify the user.

4.7.6. Description of the Hardware System

The electronic medical record consists of a database containing information about both the structure and the content of the patient's record, a user interface, and several programming modules. The system can be implemented in Windows NT/95/98/2000. We used Microsoft Access 97 database and Microsoft Visual Basic 6.0 to develop the system. A PCL 400 (Wacom) tablet monitor and digital pen (as seen in Figure 4-8) are used for history taking in the consulting room.

4.8. Summary of the EEPP Design

In this chapter we identify the disadvantages of the paper-based system and analyse the potential of an electronic medical record. A study was undertaken of the U.K. government electronic medical record project in order to anticipate integration. User identification and requirements were taken into account in the design. The system database, and user interface is optimally designed to provide a facility of retrieval/storage, a structured data entry and effective data representation.

4.9. Validation of the EEPP in the Facial Pain Clinic

This section focuses on the validation of the EEPP in a clinical setting. A clinical trial was set up to investigate the facility and acceptability of the EEPP to clinicians and patients at the Facial Pain Clinic. This section addresses the objectives, materials and methods, results, discussion, conclusion and suggestions for developing the electronic medical records.

4.9.1. Aims

The aim was to explore the acceptability of the EEPP by clinicians and patients for pain history taking in the consulting room.

4.9.2. Materials and Methods

4.9.2.1. The Clinical Setting, Patients, and Clinicians

The study was approved by the ethics committee of the Eastman Dental Hospital, University College London. The clinical trial was conducted in the Facial Pain Clinic of the Department of Oral and Maxillofacial Surgery, Eastman Dental Hospital for 11 months between May 2001 and March 2002. The eligible patients are aged 18 and over, who could communicate using English and who were referred to the clinic for chronic facial pain for the first time, or patients who were referred for the second time having been symptom free for a period of time. The patients who consented to participate were allocated into 3 groups according to the history taking method: (1) free hand, (2) FPP paper-based history, and (3) EEPP history. During the history taking using the EEPP, the researcher (P.C.) also recorded the patient history using the paper-based FPP. This was to ensure that the patient's history was not lost for any unexpected circumstance. This open design is intended to work within the framework of routine pain clinics to ensure a cohort of consecutive unselected patients, randomised to the three groups. The clinicians who participated were experienced members of the Facial Pain Clinic.

4.9.2.2. Study Instruments

The FPP is the paper-based semi-structured form used for history taking of chronic idiopathic facial pain as mentioned in Chapter 3. The EEPP is a computerised format of the FPP which includes the history, examination,

diagnosis and treatment options to be selected. Each clinician attended one training session to learn how to use the EEPP.

4.9.2.3. Outcome Measures

The time used for the consultation was recorded from the start of the history to the end of all form filling record. The patients' satisfaction with the consultation was measured using a Consultant Satisfaction Questionnaire (CSQ) immediately after consultation. The CSQ is a self-administered questionnaire developed by Baker (1990) and has been used in other clinical settings before (Richards, Sullivan, & Ross 1998). The questionnaire comprises a series of 18 questions scored from 1 to 5 on a five-point scale, where 1 indicates "strongly agree" and 5 indicates "strongly disagree". The four subscales according to groups of questions are (1) general satisfaction, (2) professional care, (3) depth of relationship, and (4) perceived time. An additional 3 questions were asked about the acceptability of the computer in the consulting room. The clinician's response to the user interface and functions of the EEPP were assessed using the modified Questionnaire for User Interface Satisfaction (QUIS) (Chin, Diehl, & Normal 1988). The modified QUIS is a self-administered nine-point rating scale with both endpoints attached with adjectives such as inconsistent/consistent. Additional questions were put to the clinicians on computer skill background, and additional comments on the EEPP. All questionnaires are documented in the Appendices A.3 and A.4.

4.9.2.4. Statistics

Statistical Package for the Social Sciences (SPSS) version 11 for Windows was used for data analysis. To test the differences of the patients' satisfaction among 3 methods of history taking, were carried out using Kruskal-Wallis statistical test and the significance level was set at $P < 0.01$. If the Kruskal-Wallis test was significant, the Wilcoxon rank sign test was used to find out the differences within 3 methods. Chi-square test was used to test for differences of demographic data among the 3 methods. One-way Anova and unpaired t-test were used for testing the difference of time taken for the history taking of 3 methods.

4.9.4. Results

4.9.4.1. Patients' Satisfaction

Four clinicians including 3 pain specialists and 1 senior nurse participated in the study. The patients were consecutively recruited into 3 methods of history taking i.e. (1) free hand (FH), (2) paper-based Facial Pain Proforma (FPP), and (3) Electronic Eastman Pain Proforma (EEPP) history. All 119 patients were included in the study. Table 4-5 shows the summary of the patients characteristics and time taken for the history taking.

Table 4-5: Summary of the patients' characteristics and time taken for the history taking

	FH history	FPP history	EEPP history
Nos. of patients	40	46	33
Gender (Female:Male)	32 : 8	40 : 6	28 : 5
Mean Age (year) with (95% Confidence Interval)	41.6 (36.9-46.3)	45.9 (40.7-51.2)	43.1 (38.4-47.9)
Diagnosis	27 FAM 6 AO 1 AFP 2 FAM/AFP 1 FAM/AO 1 AFP/OD 1 pulpitis/headache 1 oral ulcer	26 FAM 2 DDWR 2 AO 6 AFP 3 OD 3 OA 1 FAM/AO 1 AFP/TN 1 anaemia 1 Tension headache/migraine	20 FAM 3 DDWR 1 AO 7 AFP 1 OA 1 FAM/OA 1 periodontitis
Mean length of history taking (minutes) with (95% Confidence Interval)	13.2 (11.7-14.6)	17.5 (16.1-18.9)	21.8 (19.7-23.9)
Returned Questionnaires	40/40	42/46	24/33
Response rate	100%	91.3%	72.7%

The 3 groups of study are not significantly different in terms of age and gender tested by Chi-square at $P < 0.01$. Fourteen patients in the EEPP group filled in the short questionnaire about their reaction to the consultation using the computer. They were later asked to complete the CSQ sent by post. Only 5 of these 14 questionnaires were returned. Another 10 patients could not complete the questionnaire before leaving the hospital and they took the questionnaires with them to complete and return at a later time. Six of these 10 questionnaires were returned, giving the total of 106 completed questionnaires which is equivalent to an 89.08% response rate. The final group of 106 questionnaires included 40 questionnaires (100% response rate) in the free hand, 42 questionnaires (91.3% response rate) in the FPP, and 24 questionnaires (72.7% response rate) in the EEPP group. Figure 4-19 illustrates the mean length of time of the history taking with a 95% confidence Interval. The time for each method was significantly different when tested with one-way Anova and unpaired t-test.

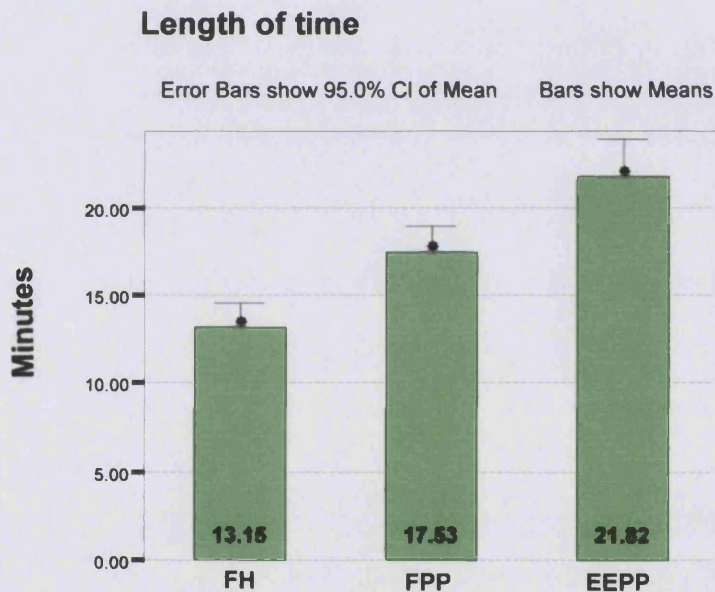


Figure 4-19: Comparison of the mean time among 3 methods of history taking. FH = free hand, FPP = paper-based Facial Pain Proforma, and EEPP = Electronic Eastman Pain Proforma are different for every group with $P < 0.01$.

The median questionnaire response scores for the three study groups are illustrated in Table 4-6. Kruskal-Wallis statistics was used to test the differences of each method. There was no significant difference among all 3 methods at $P < 0.01$ except in the “computer attitude” section. For the statement of general

attitude of using the computer in a consulting room, it was found that the median score of free hand and the FPP are significantly different to the EEPP group at $P < 0.01$.

Table 4-6: Comparison of patient satisfaction to the free hand (FH), the paper-based Facial Pain Proforma (FPP), and the Electronic Eastman Pain Proforma (EEPP) history measured by the Consultant Satisfaction Questionnaire (CSQ). Digital analogue scale: 1 = strongly agree, 2 = agree, 3 = uncertain, 4 = disagree, 5 = strongly disagree.

Statement	FH	FPP	EEPP	Kruskall-Wallis statistics	Willcoxon rank sign test
	Median (min-max)	Median (min-max)	Median (min-max)	P value	P value
General satisfaction					
1. I am totally satisfied with my visit to this doctor.	1 (1-3)	1 (1-3)	1 (1-5)	0.80	not done
7. Something about my consultation with the doctor could have been better.	4 (1-5)	4 (1-5)	4 (1-5)	0.61	not done
17. I am not completely satisfied with my visit to the doctor.	4 (1-5)	4 (1-5)	2 (1-5)	0.63	not done
Professional care					
2. This doctor was very careful to check everything when examining me.	1 (1-2)	1 (1-2)	1 (1-5)	0.30	not done
3. I will follow this doctor's advice because I think he/she is absolutely right.	2 (1-3)	1.5 (1-3)	1 (1-5)	0.72	not done
6. This doctor told me everything about my treatment.	2 (1-5)	2 (1-4)	1 (1-5)	0.43	not done
9. This doctor examined me very thoroughly.	2 (1-2)	1.5 (1-3)	2 (1-5)	0.63	not done
10. I thought this doctor took notice of me as a person.	2 (1-3)	1 (1-3)	1.5 (1-5)	0.06	not done
12. I understand my illness much better after seeing this doctor.	2 (1-4)	2 (1-4)	1 (1-5)	0.24	not done
13. This doctor was interested in me as a person, and not just my illness.	2 (1-5)	2 (1-5)	2 (1-5)	0.18	not done
Depth of relationship					
4. I felt able to tell this doctor about very personal things.	2 (1-4)	2 (1-5)	2 (1-5)	0.90	not done
8. There are some things this doctor does not know about me.	3 (1-5)	3 (1-5)	4 (1-5)	0.35	not done
14. This doctor knows all about me.	3 (1-5)	2 (1-5)	3 (1-5)	0.07	not done
15. I felt this doctor really knew what I was thinking.	3 (1-5)	2 (1-5)	3 (1-5)	0.46	not done
18. I would find it difficult to tell this doctor about some private things.	4 (2-5)	4 (1-5)	4 (1-5)	0.75	not done
Perceived time					

	FH	FPP	EEPP	Kruskall-Wallis statistics	Willcoxon rank sign test
5. The time I was able to spend with the doctor was a bit too short.	4 (1-5)	4 (1-5)	4 (2-5)	0.24	not done
11. The time I was allowed to spend with the doctor was not long enough to deal with everything I wanted.	4 (2-5)	4 (1-5)	4 (2-5)	0.50	not done
16. I wish it had been possible to spend a little longer with the doctor.	4 (2-5)	4 (1-5)	4 (1-5)	0.98	not done
Computer attitudes					
19. The use of a computer in the examination room.	3 * (1-5)	3 ** (1-5)	2 (1-5)	P < 0.01	P < 0.01
20. If given a choice, I would prefer a doctor who uses computer.	4 (1-5)	3 (2-5)	3 (1-5)	0.02	ns
21. The doctor seemed to have trouble using the computer.	na	na	3 (1-5)	not done	

na : this question is not available for free-handed and paper-based Facial Pain Proforma history taking.

ns : not significant.

* : the median score of free hand is different to the EEPP method with significant at P < 0.01.

** : the median score of paper-based Facial Pain Proforma is different to the EEPP method with significant at P < 0.01.

Table 4-7: Patients' satisfaction (n = 9) measured by the short form questionnaire. 1 = agree; 2 = neutral; 3 = disagree.

Statements	Median (min-max)
1. The use of a computer in the examination room.	1 (1-2)
2. If given a choice, I would prefer a doctor who uses computer.	1 (1-2)
3. The doctor seemed to have trouble using the computer.	3 (1-3)
4. The doctor took a thorough history.	1 (1-2)
5. The doctor was willing to listen to all my concerns.	1 (1-1)

Table 4-7 is the median score of the short form questionnaire in which responded by the EEPP group (n = 9) who did not return the CSQ. The result shows that patients are satisfied with the consulting. The demographic of the patients who returned (n = 106) and did not return questionnaire (n = 13) were tested. It was found there is no different of sex (P = 0.47) in this two groups however the mean age of patients who returned is lower (mean = 43 years with a 95% CI from 40.1 to 45.8 years) than those who did not return (mean = 49.4 years with a 95% CI from 38 to 60.8 years).

The patients' comments on each method of consultation are shown in Tables 4-8, 4-9, and 4-10.

Table 4-8: Summary of patients' comments after the consultation using free hand history taking.

Types	Patient's Comments
Positive	<ul style="list-style-type: none"> • Doctor: helpful, friendly, polite, warm, good sense of humour, and understanding. • Consultation: useful, informative. • Examination is thorough. • Reassurance and explanation is satisfied. • Overall: happy with this visit, efficient, thorough, and grateful for the visit.
Negative	<ul style="list-style-type: none"> • Waiting time is long.
Neutral or comment on computers	<ul style="list-style-type: none"> • I don't understand the role a computer would play in a consultation. • To choose a doctor, it depends on performance of the doctor to deal with and operate a patient rather than on the one who uses a computer (This comment is actually on the question 20 in the Consultation Satisfaction Questionnaire).

Table 4-8 shows that clinician personality is important for patients' satisfaction as seen in most of the positive comments. In the free hand history taking, some patients were perplexed with the role of computers in consultation. All 15 comments are positive for the consultation received.

Table 4-9: Summary of patients' comments after the consultation using paper-based FPP history.

Types	Patient's Comments
Positive	<ul style="list-style-type: none"> • Doctor: nice, easy to talk with, good manner, thoughtful, considerate, and careful. • Consultation: informative, thorough, clear explanation. • Overall visit: excellent, pleased with the visit, very satisfied, happy to visit, well handled, efficient, positive session.
Negative	<ul style="list-style-type: none"> • The questionnaire did not seem to cover my description of the problem as accurately as needed to be compared to other problems. This is ok. As long as there is a space for extra comments/other on the computer system in order to account for important difference. • The satisfaction questionnaire needs to be changed.
Neutral or comments on computer	<ul style="list-style-type: none"> • I don't think that using computers or not makes any difference. It is more important that the doctor is careful when taking notes and if they are transferred to a computer, they should be done accurately. • Unless the treatment works, I am not sure whether I agree with the doctor entirely or not

Table 4-9 shows that patient satisfaction depends on the doctor's personality. Ten out of twelve comments were positive, one is negative with the FPP and another with the satisfaction questionnaire, and one is neutral for the consultation.

Table 4-10: Summary of patients' comments after consultation using the EEPP.

Types	Patient's Comments
Positive	<ul style="list-style-type: none"> • Doctor: friendly, thorough explained carefully, treated me as a person in pain, superb, satisfied with the way doctor approached, thoughtful, easy to talk. • Examination: satisfied • Reassurance: authentic • Overall: satisfied, nice, professional. • I am comfortable with using computer assisting consultation. If possible, I like a small computer more than the big one.

Types	Patient's Comments
	<ul style="list-style-type: none"> Bearing in mind the elusive nature of my complaint, I think the doctor made a thoughtful and "modern" diagnosis which I am happy with.
Negative	<ul style="list-style-type: none"> Going through questions on a computer, I realise that it is important but really time consuming and your answers need to fit within the computers categories which they don't always do. The doctor pursue questionnaire as directed and managed by the laptop computer and hardly look at the patient. The patients felt that the questionnaire did not elicit her problems. It seems that the patient felt the doctor did not listen to her as the doctor just follow the process to complete the questionnaire in the computer.
Neutral	<ul style="list-style-type: none"> It took quite a while using the computer system but I think next time it will benefit the next consultant more. Many thanks to see me and reassuring me regarding my teeth. However I do not believe in the solution to my problems was a correct diagnosis. The problem relates to the use of the computer relate solely to the ability of the doctors use of the computer program. This did not seem to have any effect on his judgement.

4.9.4.2. Clinicians' Satisfaction

Four clinicians who participated in the study comprise of 3 pain specialists and 1 senior nurse. Table 4-11 shows the computer skill background of the clinicians.

Table 4-11: Clinicians' computer background.

Statement	Clinician 1	Clinician 2	Clinician 3	Clinician 4
Level of computer experience	quite good	intermediate	intermediate	quite good
Experience with the computerised medical record	no	no	no	no
Describe computer experience	word processing, spreadsheet (Excel), power point, SPSS	word processing, commercial package of patient data base, internet, e-mail	word processing	word processing, power point, e-mail daily

Clinicians' responses measured by the modified Questionnaire for User Interface Satisfaction (QUIS) are shown in Figures 4-20, 4-21, 4-22, 4-23, and 4-24.

Overall User Reactions

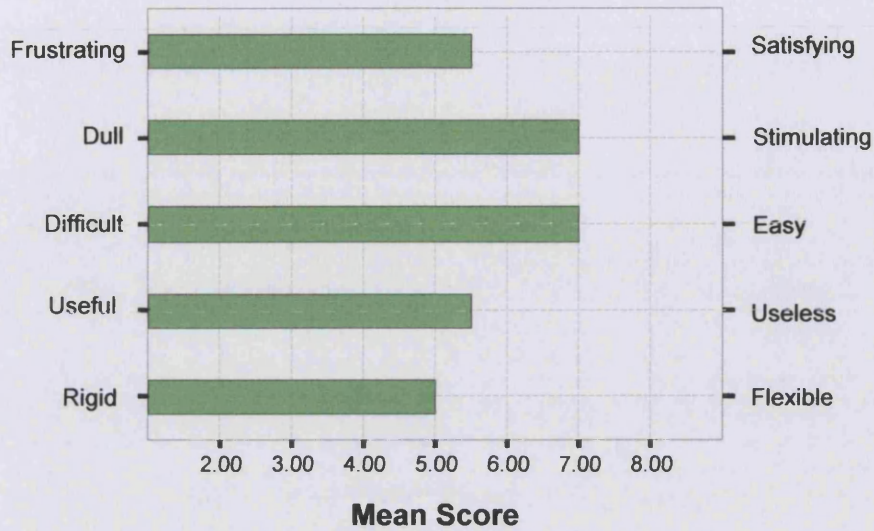


Figure 4-20: The overall user reactions to the EEPP interface. The scale is nine point rating scale starting from 1 to 9.

Screen Design & Layout

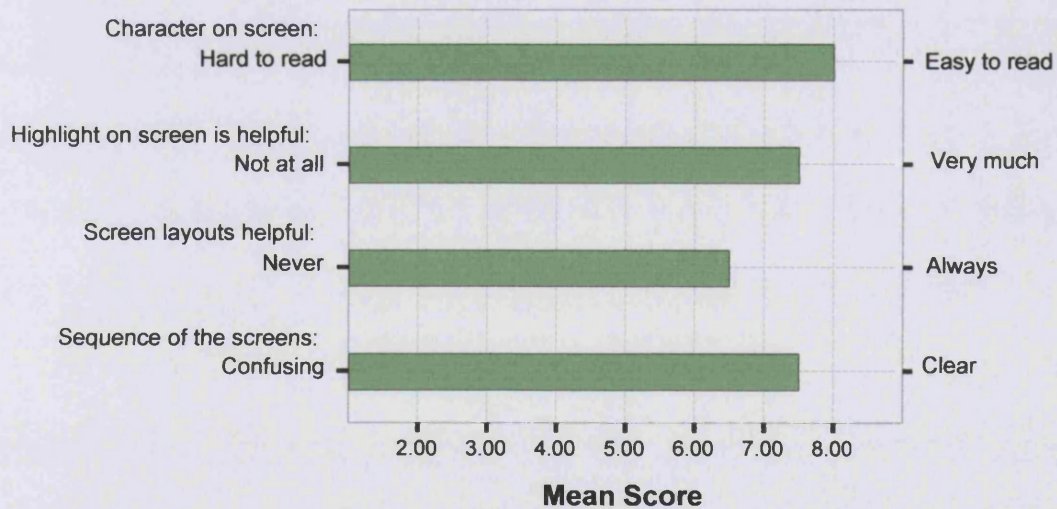


Figure 4-21: Clinicians' responses to screen design & layout of the EEPP. The scale is a nine-point rating scale starting from 1 to 9.

Screen Terminology

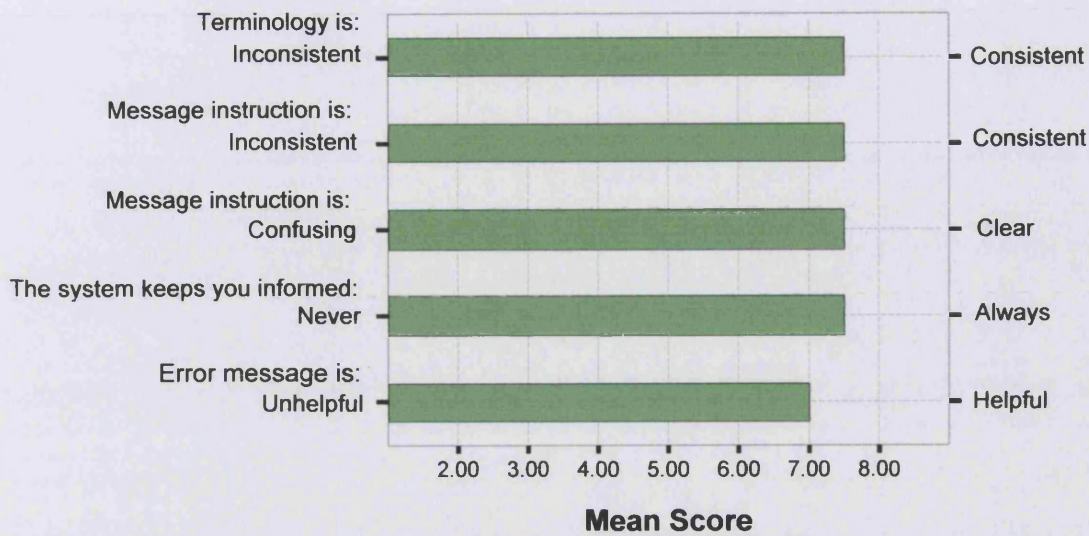


Figure 4-22: Clinicians' responses to screen terminology of the EEPP. The scale is a nine-point rating scale starting from 1 to 9.

System Learning

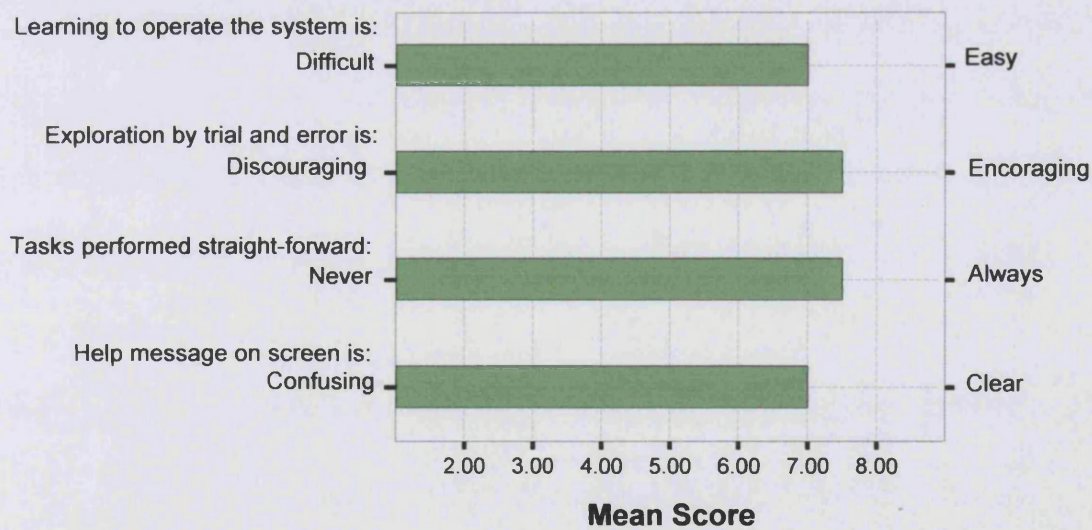


Figure 4-23: Clinicians' responses to the difficulty of learning to operate the EEPP. The scale is a nine-point rating scale starting from 1 to 9.

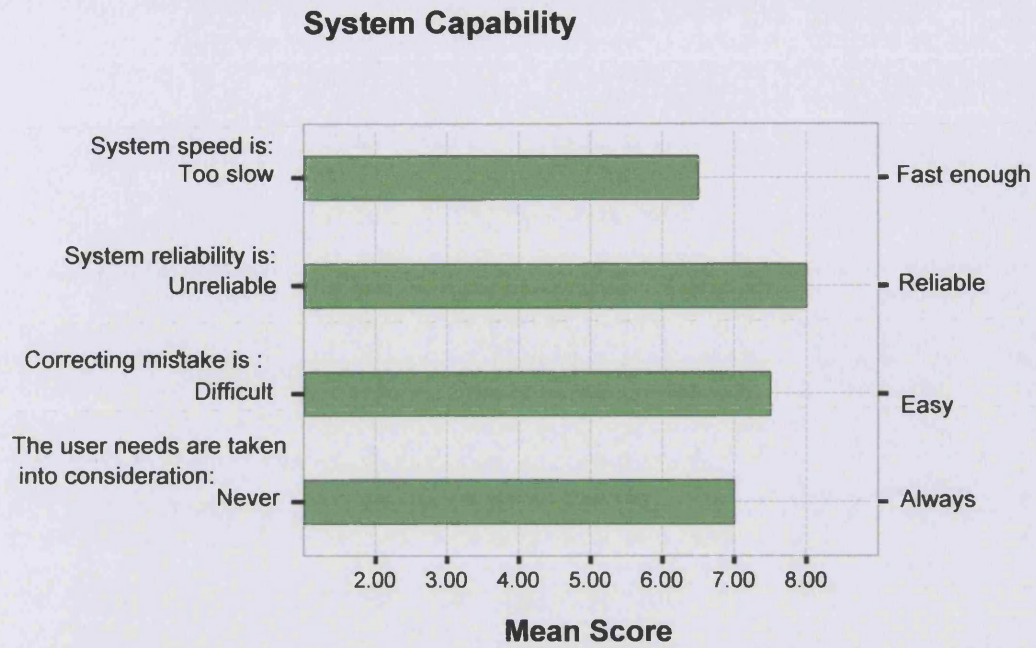


Figure 4-24: Clinicians' responses to the EEPP system capability. The scale is a nine point rating scale starting from 1 to 9.

The clinicians' comments on the EEPP and clinicians' attitude to electronic medical record in general are shown in Table 4-12.

Table 4-12: Clinicians' comments on the EEPP.

Statement	Clinician 1	Clinician 2	Clinician 3	Clinician 4
1.Does the electronic medical record sound like a good idea.	agree	uncertain	uncertain	strongly agree
2.The questions in the EEPP help to lead you to the diagnosis of facial pain	disagree	uncertain	uncertain	agree
3.Your reasons for your answer to question 2	Because all aspects of the history cannot be viewed at a glance on a single page.	Because I usually have a preconceived idea about the diagnosis.	Because It does not form pathway of diagnosis.	It needs to validate the system.
4.Could you find your way round the EEPP easily	agree	strongly agree	agree	agree
5.How would you rate the EEPP overall from 4 point rating scale.	3 out of 4	3 out of 4	2 out of 4	3 out of 4

Statement	Clinician 1	Clinician 2	Clinician 3	Clinician 4
6.How could the EEPP be improved	<ul style="list-style-type: none"> • To print off information on each patient • To print off summary information in graphical or tabular form on a group of patients to compare data findings. • To develop the programme for use by trainees learning to take pain histories to test their diagnostic decision making and to determine whether they reach the correct diagnosis when presented with a set of history. 	<ul style="list-style-type: none"> • To be used as a decision tree to arrive at a diagnosis and treatment planning • To shorten the family history as well as past and present medical history 	<ul style="list-style-type: none"> • To incorporate a clinical pathway 	<ul style="list-style-type: none"> • To refine the EEPP

4.9.5. Discussion

This study explored the use of the Electronic Eastman Pain Proforma for collecting a pain history from patients in a clinical setting. The most striking result from this study is that the doctor's use of computers during the consultation was not associated with a decline in the quality of the doctor-patient relationship. There has been concern that a doctor's use of a computer during a consultation can prevent the development of an empathetic relationship (Mitchell & Sullivan 2001), (Thornett 2001). One reason is the fear that the doctor will spend more time looking at the computer than attending to the patient. In this study, the scores in the statements of "depth of relationship" were not significantly different between the study groups. These findings are in agreement with prior studies (Legler & Oates 1993), (Aydin et al. 1995), (Richards, Sullivan, & Ross 1998). Patient satisfaction is affected by many factors and not simply whether or not a computer was used in the consultation. Other studies have shown that these include the patients' perception on the length of time spent for the consultation (Cape 2002), communicative behaviour of the clinicians (Schouten, Eijkman, & Hoogstraten 2003), the patients' perception of the doctors' empathy (Mercer, Reilly, & Watt 2002) shown by the affective quality of the clinician's manner, the amount of information conveyed, and the clinician's technical and interpersonal skills (Lewis 1994). The result of the questionnaire demonstrated that other aspects of doctor-patient relationship such as "general satisfaction", "professional care", and "perceived time" were not significantly different among our study groups. The qualitative analysis of the patients' comments in our study also showed that the satisfaction depended on the doctor's manner and communication skill. Almost all the patients supported the use of a computer for history taking and they considered that the doctor's judgement was not affected by to use or not use the computer. The patients' attitude to the statement "The use of a computer in the examination room" in the "computer attitudes" section (see Table 4-5) was naturally more meaningful within the patients in the EEPP group for which these patients were exposed to the use of computer for history taking. One exceptional patient demonstrated her anger to the doctor using the EEPP and to the history taking lead by the questions in the EEPP. This exceptional case can be sporadically found in any Facial Pain Clinic when facing patients who are extremely anxious

or may have somatoform disorder and are determined to “sell” their own diagnosis.

The increased consultation time from the free hand to the EEPP in this study is expected because of the increased number of questions to be asked in the semi-structure questionnaire and the time the doctor spent interacting with the computer. Nearly all the clinicians, took only 5 patients for the EEPP method, and on the first to the third case, the clinician spent longer time than the later cases with the EEPP demonstrating a learning curve. The increase of consultation time may be seen as a drawback to the use of a computer since the patient satisfaction does not increase when compared to not using computer in general practice (Richards, Sullivan, & Ross 1998). However, the other factor which should not be overlooked is the clinical data content and quality. The cross-sectional study of Hippisley-Cox et al (2003) on general practice medical records in the Trent region clearly indicated that the quality of clinical data in electronic medical record was significantly better than those of the free hand medical record in terms of the understandable and legible content of the clinical data, the amount of clinical content, the notification of advice and specialty referral, and doses of the drug prescribed. Additionally, the doctors used the electronic medical record were able to recall more advice given to patients than those who did not. If such a electronic medical record are fully implemented time to make a summary of the patient history, letters, and data analysis would be saved.

The clinicians who participated in this study had intermediate to quite good computer skills but they had never experienced an electronic medical record before. The clinicians' satisfaction on the EEPP interface was measured using the modified Questionnaire for User Interface Satisfaction (QUIS). This questionnaire measures 5 aspects of the interface i.e. overall reaction to the system, screen design and layout, terminology on the screen, difficulty to learn the system, and system capability. The mean scores of all these aspects show satisfaction, that is more than half of the score and some score quite good including the screen design and layout, terminology on screen, system learning, and system capability. Although the clinicians were positive to the concept of the electronic medical record, some were not clear about the definition and function of the electronic medical record. There was no consensus about

capacity of the EEPP to help make the diagnosis and each participant gave different reasons. For example, lack of a summary of the patient history by the EEPP, lack of the pathway leading to the diagnosis, and the preconceived diagnosis of the clinician. The layout of visible tabs for different history pages of the EEPP was accepted to be easy to navigate. The mean score of the EEPP is equivalent to 2.8 out of 4.

The clinicians' suggestions for further development of the EEPP were

- To shorten the family history and medical history
- To print a summary of the patient history
- To create an analysis of the patients symptoms, diagnoses and efficacy of treatment
- To develop an interactive educational programme for trainees in orofacial pain.
- To incorporate a clinical guideline for diagnosis and management
- To integrate the interactive decision tree for leading the clinician to arrive at a diagnosis and treatment plan for a particular patient.

Several limitations of this study should be mentioned. Patients were not randomised into study groups but used by consecutive allocation to the three groups. This arose from initial reluctance by some clinicians to commit themselves to the EEPP. Also we can not think of any way to blind the clinicians and patients from the comparative nature of history taking in the consulting room. As the EEPP was an ongoing developing computer programme, it is impossible to expect it to function at the same level as a commercial software programme developed by a team of programmers professionally trained working together in a systematic fashion. Despite this the outcome was reassuring.

4.9.6. Conclusions

This study demonstrated that the use of the computerised proforma for taking the pain history in the consulting room did not result in a decrease in the patient-doctor relationship and was accepted by all patients. A computerised proforma could provide guidance by leading the clinician with its questions. The choices of possible answers can be designed to be hidden in the screen

interface and are only available when the user needs it. This feature makes the computerised proforma more compact than the paper-based proforma. Also the teaching of a detailed chronic idiopathic facial pain history is more dynamic than by using a paper-based or free hand approach. The clinicians were positive to the concept of the electronic medical record and rated their overall satisfaction at 2.8 out of 4. The response of the clinicians to the EEPP interface design was good. The clinicians participated in the further development of the EEPP by suggesting their required functions. Although a computerised system is a way of collecting data leading to a diagnosis, it still requires a basic understanding of the problem of chronic idiopathic facial pain and an understanding of its aetiology. We suspect that a nurse using such a system without specialist knowledge may not be successful, but this remains to be tested.

It is impossible to explore and develop every aspect of the electronic medical record in detail. Hence, future work needs to be done to develop a fully functioning electronic medical record with embedded decision support systems for diagnosis and patient management.

CHAPTER 5

CLINICAL DECISION SUPPORT SYSTEM FOR THE DIAGNOSIS OF CIFP

5.1. Introduction

The considerable advances in computer science in the last century have dramatically changed modes of work. Medicine, for example, has employed information technology to improve patient care. Computerised decision support systems for medical care have been implemented since the early 1950s and continue to be developed. One reason for developing such decision support systems is to help the new generation of medical practitioners to cope with the expanding information overload (McDonald 1976). With the rapid growth of the internet and the increasing need for evidence-based medicine for best practice, this will facilitate for development of computer-based decision support systems. These systems can assist health care systems and clinicians, access relevant information, and reduce time constraints – issues that are barriers to the integration of the best available evidence into daily practice. This chapter explains the basics of clinical decision support systems and human clinical diagnostic reasoning. Furthermore, the chapter gives a brief overview of the history of decision support systems. The last part of the chapter describes a decision tree for the diagnosis of chronic idiopathic facial pain arising from this study.

5.2. Definition of Clinical Decision Support Systems

In the literature, the three terminologies, expert system, knowledge-based system, and decision support system are often used interchangeably. Jackson (1999) defines an expert system as follows;

'An expert system is a computer program that represents and reasons with knowledge of some specialist subject with a view to solving problems or giving advice.'

Thus 'Expert Systems' process knowledge and solve problems like a human expert. A non-expert can use an expert system to improve his or her abilities to solve complex problems by simulating a dialogue with experts in a particular field. Expert systems arose from research in the discipline of 'Artificial Intelligence' in the 1970s. Artificial Intelligence is a branch of Computer Science concerned with the design and implementation of programs which try to imitate and reproduce human cognitive skills such as problem solving, visual perception, and language understanding (Jackson 1999). Expert systems have been applied to a diverse range of subjects including engineering, robotics, computer system configuration, and biomedicine. The term 'expert system' describes what this system aspires to be, not necessarily what they are. This terminology in some sense is intimidating and neglects the ability of the users. It leads to reactions ranging from anxiety to fear of replacement from users. It must be emphasised that such an expert system is typically used to assist and not to replace the clinician.

The term knowledge-based system is sometimes used as a synonym for 'expert system'. It is ubiquitous in Europe whereas the term 'expert system' is predominant in U.S.A. (Hammond, Davenport, & Potts 1993). Smith (1996) defined knowledge-based system as a computer system which embodies knowledge about a specific problem domain and can be used to apply this knowledge to solve problems from the problem domain. He defined expert systems as knowledge-based systems that behave in a similar manner to a human expert when solving problems. Thus, an intelligent database system may be knowledge-based, but it is not necessarily an expert system, because it has not been designed to use its expertise to solve problems in similar manner of a human expert and also its knowledge has not been transferred from the human expert's expertise. It is instead designed for easy access to the information stored in its database.

In recent years, the term 'Decision Support System (DSS)' has become more popular. The origins of DSS are found in the discipline of management science in the early 1970s and the term 'decision support system' was coined later in

1989 (Marakas 1999). The term DSS seems to be more optimistic and less provocative than the term expert system. The definitions of DSS were defined by many authors as below.

Srinivasan et al. (2000) have defined as:

'Decision Support System (DSS) is a computer-based aid for decision making involved in solving problems of some complexity.'

Marakas (1999) defines a DSS more generally as:

'A system under the control of one or more decision makers that assists in the activity of decision making by providing an organised set of tools intended to impart structure to portions of the decision-making situation and to improve the ultimate effectiveness of the decision outcome.'

The term DSS is similar to the term knowledge-based system as any system that embodies knowledge for solving particular problems may be considered as a DSS. For example, the database that has functionality for searching what users query from the database to assist their decisions.

A number of definitions for 'Clinical Decision Support Systems (CDSS)' have been proposed. Shortliffe (1987) has proposed the following simple definition:

'Any computer program that deals with clinical data or medical knowledge and which performs one or more of the following tasks: serving as a tool for information management; helping health-care workers to focus attention; or giving advice in the form of a patient-specific consultation.'

Wyatt and Spiegelhalter (1990) provide an alternative:

'An active knowledge system which uses two or more items of patient data to generate case-specific advice.'

Hunt et al. (1998) similarly defined it as:

'An active system which synthesises and integrates patient-specific information performs complex evaluations and presents the results to clinicians in real-time.'

However, CDSS can include 'passive' system. Despite not being patient specific, passive systems provide valuable support by improving access to information and guidelines of care (Coiera 1997). Examples of the passive

systems are medical literature search systems such as MEDLINE, drug databases like BNF online, websites which provide guideline of healthcare such as prodigy, other exclusive systems that provide access to information for evidence-based practice via internet such as Cochrane (can be in CD-ROM), and Bandolier.

Moreover, the medical profession has adopted passive CDSS for facilitating and improving processes of work. Laboratory data management software, drug information management systems, systems for patient administration, mechanical ventilators, and oxygen saturation measurement devices are among the many types of computerised systems that have become an integral part of the modern hospital. These devices and systems capture, transform, display, or analyse data for use in clinical decision making. Furthermore, using the computerised medical record to improve the legibility, display, and accessibility of information in patient medical records may count as decision support because it serves to improve clinical practice and quality of care.

The class of CDSS can be subdivided according to their medical functionality (Randolph et al. 1999);

- alerting; the system that monitors and highlights abnormalities out of the normal range such as laboratory values.
- reminding; the system that notifies clinicians of important tasks such as reminding clinicians to schedule cancer patient review.
- critiquing; the system that evaluates the clinician decision making such as critiquing when clinicians order blood transfusion to patients with high haemoglobin.
- interpreting; the system that interprets the electrocardiogram by generating a report of a patients condition using clinical data and the electrocardiogram pattern.
- predicting; the system that predicts the risk of mortality from a severity of illness score such as head trauma.
- diagnosing; the system that lists a differential diagnosis for a patient with abdominal pain.

- assisting; the system that gives instructions for the caregivers about how to manage the ventilation of patient with adult respiratory distress syndrome.
- suggesting; the system that makes suggestions about the optimal decision based on the information currently known by the system and clinical data of specific patient such as the systems which give suggestions for antibiotic ordering in term of treatment and cost effectiveness.

5.3. Clinical Diagnostic Reasoning

The aim of this section is to describe the important aspects of human reasoning and in particular clinical diagnostic reasoning.

5.3.1. Definition of Diagnosis

The medical diagnostic process typically proceeds as follows:

- The patient presents to the clinician with a set of complaints (symptoms and signs)
- The clinician elicits information characterising the present illness, as well as data regarding past illnesses, personal habits (e.g. alcohol and cigarette consumption), family history (to investigate inherited conditions), and psychosocial history.
- The clinician performs a physical examination of the patient to determine the presence or absence of certain identifiable signs of disease.
- In some cases, the clinician may order appropriate tests. He/She then comes to a conclusion concerning the diagnosis.

A correct diagnosis will allow the clinician to choose the most effective treatments to ameliorate the disease, and to give an accurate prognosis.

Diagnosis is a complex process and involves sophisticated clinical reasoning to produce an interpretation of the patients. The medical problems reflect the difficulty and the diversity of factors that need to be taken into account in medical decision-making. In addition, it is well recognised that there is always uncertainty in medicine. The uncertainty arises not only because of incomplete

knowledge but also from the quality of the information gathered and the complexity of the situation, such as the subjectivity of the information (the patient) and the investigator (the doctor).

5.3.2. Investigation and Interpretation of Clinical Diagnostic Reasoning

How do clinicians make a diagnosis? Researchers in cognitive psychology have analysed the decision steps and thought processes of clinicians as they attempt to solve clinical problems. Shanteau (1987) identified important positive characteristics from experts during his observation of an expert's decision-making process (quoted by Fox et al. 2001).

'First, they (experts) know what is relevant to specific decisions, what to attend to in a busy environment, and they know when to make exceptions to general rules. Secondly, experts know a lot about what they know, and can make decisions about their own decision processes: they know which decision to make and when, and which to skip, for example. They often have good communication skills and the ability to articulate their decisions and how they arrived at them. They can adapt to changing task conditions, and are frequently able to find novel solutions to problems.'

To gain a clearer picture of human clinical reasoning, the psychological concept of bounded or limited rationality by Newell and Simon (1972) has been used by Elstein and Bordage (1988). This emphasises the limitation of the human capacity for rational thought. In considering clinical reasoning, the most relevant limit is the relatively small capacity of working memory compared to long-term memory. This means that over a short period of time, we cannot work efficiently with all we know about a problem or all the data that could be collected. Because of this limit, one needs to select data carefully, and process and present them in simplified ways.

To understand human cognitive process in clinical reasoning, two approaches namely problem solving and decision making are used for explanation (Elstein & Schwatz 2002). These approaches describe a psychological process in solving diagnostic problem and review errors and pitfalls which can occur in diagnostic reasoning.

5.3.2.1. Problem Solving Approach

Problem solving research aims at studying reasoning of experts to improve clinical reasoning of medical students and trainees. Various models in problem solving strategy arising from research explain the process of clinical reasoning. Three such models are considered in the subsections below:

Model 1: Hypothetico-deductive reasoning

According to Elstein et al. (1988) who proposed this model, diagnosis is defined as a process of testing hypotheses. Clinicians solve the diagnostic problem by using the hypothetico-deductive reasoning approach which indicates that hypotheses are derived based on clinical data and knowledge. Then, the hypotheses are tested through the process of data collecting from the patient. The four major components of this reasoning process are described as follow.

1. Acquisition of information. Information is obtained by the clinician by a variety of methods, such as taking a history, performing a physical examination, or administering a battery of laboratory or psychological tests.
2. Hypothesis generation. A hypothesis is an alternative problem formulation. It is generated by using limited data to link to the clinician's long term memory store. It transforms an unstructured problem into a structured problem by generating a small set of possible solutions (or hypotheses), of the order of four or five. The hypotheses allow the organisation of available data and thus extend the human capacity to memorise a large amount of data. This early generation of hypotheses seems to be the strategy most commonly used by clinicians involved in diagnosis.
3. Information interpretation. The data obtained must be interpreted in the light of the hypotheses being considered. To what extent do the data strengthen or weaken belief in the correctness of a particular hypothesis? The accuracy of data interpretation is not always correlated with the data collection. A clinician could collect data thoroughly but interpret the data incorrectly, or misunderstand a significant key point. On the other hand, a clinician may collect frugal data but could interpret it accurately. Nevertheless, the accuracy of diagnosis depends on both variables.

4. Hypothesis evaluation. After having interpreted the data, the pros and cons for each alternative hypothesis are added. Then, the clinician must reach a diagnostic judgement. If not, the problem is reconsidered, new hypotheses are formulated and, if necessary, new data are elicited.

Model 2: Pattern recognition or categorisation

Pattern recognition involves pattern interpretation. It is essentially the process of recognising the similarity between a set of signs and symptoms from previous cases. Then a case is assigned to a category. There are two types of categories. The first category is instance based recognition (or exemplar based recognition) in which a new case is categorised by its resemblance to memories of instances. The second category is similar to the first but more integration between domain-specific knowledge and skills in cognition called an abstract prototype which is constructed using clinical experience to facilitate an abstraction. The knowledge of expertise is developed mainly from changing the knowledge structure based on learning from the observation from clinical experience. The transition from medical student to expert clinician requires placing biomedical knowledge into clinically relevant concept groups of focus. The basic biomedical knowledge is restructured around illness scripts and then finally to create a representative of scripts which is more abstract and generalised. An expert sees new cases that strongly resemble patients previously seen. Thus, expert reasoning in non-problematic situations looks more like pattern recognition or direct automatic retrieval from a well-structured store of knowledge (Groen & Patel 1985). The difference between an expert and a novice are that firstly, an expert has various storing instances in memory and secondly, an expert has constructed more generalised and abstract sets of semantic relations.

The choice of strategy for diagnostic problem solving depends upon the perceived difficulty of cases. Easy cases can be solved by pattern recognition: difficult cases need hypothetico-deductive method. Difficult or easy is judged by the knowledge and experience of the clinician.

5.3.2.2. Decision Making Approach

Problem solving strategy does not prove to prevent errors in the diagnostic process (Elstein & Schwartz 2002). Decision research uses statistics to reason uncertainty. From decision theory standpoint, diagnosis is viewed as opinion revision with imperfect information and employs Bayes's theorem as a standard rule for this task (Elstein & Schwartz 2002). Spiegelhalter et al. (1999) defined Bayes's theorem as a formula that shows how existing beliefs, formally expressed as probability distributions, are modified by new information. For example, a doctor wants to know the probability of a patient who has a particular symptom to be diagnosed as having a particular disease if a doctor has prior belief about the prevalence of the disease in the community. The prior probability is either the known prevalence of the disease or the clinician's subjective impression of the probability of disease. The post-test probability of disease is based on two variables, prior probability and the strength of the evidence, measured by a likelihood ratio. Therefore, error of decision making based on Bayes's theorem can come from two sources, prior probability and strength of the evidence. Heuristics and biases in estimation and revision of probability can be found in this approach including: (i) vivid or easily recalled events and serious conditions tend to be overestimated, (ii) collecting facts as consistent with a favoured hypothesis, (iii) overemphasising positive findings, and discounting negative findings, (iv) later presented information in a case is given more weight than earlier presented information (Elstein & Schwartz 2002).

To this extent, study of the reasoning processes is very instructive and can lead to formalisation of medical expertise and therefore allows clinicians to understand better what they know. In the long term, it lays down the knowledge for the development of different strategies for solving clinical problems. In different circumstances, some approaches may be more appropriate than others. Thus, the development of computer based diagnostic programs requires an understanding of human reasoning. Blois (1980) suggested that the decision support system was best applied to well structured problems, that is at the stage of hypothesis testing in the hypothetico-deductive model of clinical reasoning.

5.4. A Review Literature of CDSS

This section aims to review previous research of CDSS. In particular, systems for the diagnosis of headache and facial pain are discussed.

5.4.1. Historical Survey of CDSS in Medicine

All of the major events in developing CDSS have occurred in the medical community; therefore a survey of CDSS in medicine gives an overview of the significant steps in CDSS development. The first generation of computerised clinical decision support systems appeared in the late 1950s. An early work of significance in CDSS development was a study of reasoning methods in medical diagnosis by Ledley and Lusted (Ledley & Lusted 1959). They investigated the way clinicians make diagnoses by studying from clinical problem solving of Clinico-Pathological Conference (CPC) in the New England Journal of Medicine. They concluded that clinicians have an imperfect knowledge of how they solve diagnostic problems. They stated that both logic and probabilistic reasoning were important components of medical reasoning. The application of computers combined with the use of algorithms designed to simulate human cognitive diagnostic processes were discussed. The study of Ledley and Lusted laid the foundation for diagnostic CDSS to two different approaches for solving problems, firstly a system with logical approaches such as set theory and Boolean algebra, and secondly a system with probabilistic approaches such as the Bayes's theorem. A well known and widely used system for the diagnosis was the system for the diagnosis of abdominal pain developed by de Dombal et al. (1972) . This system employed Bayesian classification, a modification of Bayes's theorem of independent conditional probability. Bayesian classification is used widely in developmental CDSS. Bayesian has some shortcomings of algorithmic systems such as the deficiency of an explanation facility as the diagnosis is concluded. Attempts to overcome some of the shortcomings of algorithms and improve the function of CDSS led to the development of heuristic diagnosis systems. According to the comprehensive review of Miller and Geissbuhler (1999) , Gorry was the first to develop heuristic diagnostic systems that employ symbolic reasoning. Such systems are based on qualitative judgements achieved by logical deduction or 'heuristics' in contrast to numerical calculation systems whose power comes

from the analytical mathematics equations used. For example, rule-based decision support systems infer a conclusion by using if-then rules. Other symbolic reasoning systems employ frames and semantic nets. Many diagnostic systems, developed later in the 1970s and 1980s, also employed symbolic reasoning. In 1973, Shortliffe et al. introduced MYCIN, a heuristic rule-based system for diagnosis and treatment of bacterial infectious disease (Shortliffe, Axline, & Buchanan 1973). MYCIN represented a landmark study in the field of computerised medical diagnostic CDSS. It became a gold standard for many heuristic rule-based systems that were developed later. In 1980s and 1990s, several new techniques have been used such as fuzzy set theory and Bayesian belief networks. Neural networks recently represent a new approach to medical diagnosis using mathematics and statistics to learn from the training case. Then the learnt knowledge will apply to diagnose unseen cases.

The style of diagnostic consultation of the early systems (1970s-1980s) was described as the “Greek Oracle”. The approach ignored the clinician’s knowledge and treated clinicians as if unable to solve the problem. By the late 1980s and early 1990s, developers turned to a critiquing style which was first developed by Miller (1984). Here, the clinician proposed a solution which the computer evaluated and if necessary generated an appropriate criticism or alternative suggestion. In the 1980’s and 1990’s, diagnostic reasoning has been modelled in a more formal and often mathematical fashion combining clinical knowledge with mathematics model or artificial intelligence. Examples of this reasoning are fuzzy set theory and neural network.

There are three ways in which CDSS interact with the user (Marakas 1999). Firstly, some systems are stand alone and simply require direct data entry by the user. This is the characteristics of early systems. Secondly, there are systems that connect directly to electronic devices to generate patient data, such as monitors of serum electrolyte levels. Thirdly, other systems integrate with computer-based patient records and obtain data directly from the patient record. There is a belief that the second and third methods of interaction will increase (Mitchell & Sullivan 2001).

5.4.2. Impact of CDSS on Practice: Experience from Medicine

The substantial advances in the development of CDSS for medical care have been increasing in parallel to the advances of computer science and information technology since the 1980s. There are considerable studies of CDSS present in the literature, however only a small number of them have been further developed and evaluated in the clinical setting. CDSSs have been employed in various degrees in many areas of medicine. Most of them are in academic research and primary health care.

The researchers from McMaster University Medical Centre have systematically reviewed controlled clinical trials assessing the effects of computer-based CDSS from 1974 to 1998 on clinician performance and patient outcome (Johnston et al. 1994) (Hunt et al. 1998). It was noticed that the quality of the research is improved because the eligible studies during 1992 – 1998 increased nearly twofold over the studies during 1974 – 1992. Sixty-eight studies were included, of which 19 examined preventive cares, 15 examined drug dosing systems, 26 examined clinical management, and 5 examined diagnostic aid systems. It was found that the use of computer-based CDSSs lead to significant improvements on preventive care, drug dosage, and the general clinical management of patients but slightly improving the diagnosis. There are positive effects of using CDSSs to health care practitioners' performance in the majority of the studies.

Mitchell and Sullivan (2001) have systematically reviewed the published articles on primary care CDSSs during 1980 –1997. The objectives of this study are twofold; firstly, to investigate the effect of CDSS on clinicians' performance and patients' outcome; secondly, to investigate attitudes towards CDSS. The impact of CDSS to clinicians' performance and patients' outcome is similar to the studies of the McMaster University. They found that the CDSS had a positive effect to clinicians' performance in all of the tasks such as consultation, immunisation and preventive care, disease management, and drug prescribing. However, the length of consultation increased at the beginning but decreased later. Patient satisfaction was not significantly changed when computers were introduced. In relation to practitioners' and patients' attitudes, most practitioners were willing to accept computers as part of their work and were positive about

their use. Patient thought that computers assisted their doctor to access records and that consultations were unaffected. However, there were some concerns about using computers such as privacy, the doctor-patient relationship, cost, time, and training.

Balas et al. (1996) reviewed the literature of randomised controlled studies to assess the efficacy of computerised information systems. They also found that provider/prompts, computer assisted treatment planners, and interactive patient/education therapy and patient prompts were successful significant interventions without a bias affected by unpublished negative studies.

Shea et al. (1996) studied the effectiveness of computer-based reminder systems on preventive care using meta-analysis on 16 randomised controlled trials. The study indicated that manual and computer reminders separately increase the use of preventive services and were more effective in combined intervention.

From these systematic reviews, it is clear that CDSS have a promising future in improving the health care system and patient care.

5.4.3. Applications of Diagnostic CDSS in Medicine

There have been a lot of applications of diagnostic CDSS in medicine since it was originally developed. Some systems are broad knowledge-based domains such as the diagnosis of diseases in internal medicine e.g. QMR (Quick Medical Reference) (Miller, Masarie, & Myers 1986), Iliad (Warner 1989), and Dxpain (Barnett et al. 1987). Others are more specific domain such as the system for diagnosis of acute abdominal pain (de Dombal et al. 1972), chest pain (Wyatt 1989), and Mycin for diagnosis of infection (Shortliffe, Axline, & Buchanan 1973). Most of the systems are developed in the academic environment and some systems are further developed commercially. Some examples of systems which are still active and widely used are detailed here.

QMR was constructed using the knowledge-based structure and inference of Internist-I. It uses a heuristic algorithm that requires that each finding include information of what is called its “evoking strength” and “frequency”. Evoking strength measures how strongly the presence of the finding should trigger or evoke consideration of the disease. The expert uses the medical literature to

assign a value ranged from 0-5 for the evoking strength of each finding, with 0 used for nonspecific findings and 5 used for pathognomonic findings. Finding frequency is ranged from 1-5.

Dxplain uses Bayes's theorem for diagnosis of 2000 disease entities in internal medicine. It has 2 versions, a stand alone program and web based version runs underlicensing of Harvard University (<http://www.lcs.mgh.harvard.edu/dxplain.htm>).

The diagnostic capability of CDSS has been used in education for health care students and medical house officers training. Some systems have been implemented in hospital information system such as HELP system located in the hospital in Salt Lake City and developed by the member of the Department of Medical Informatics of the University of Utah (Haug, Gardner, & Evans 1998). Examples of CDSS in HELP are the Adverse Drug Events (ADEs) for analysing whether patients are prone to adverse drug interaction; nosocomial infection detection system; and antibiotic assistance to help clinicians diagnose infection and suggest appropriate treatment.

The literature reviews of the McMaster University (previously mentioned) have revealed that most of the diagnostic CDSS (4 out of 5 studies) demonstrated an unconvincing impact on clinical practice. It is clearly seen from their study that good research on the use of diagnostic CDSS in a clinical setting is needed. Their conclusion on the diagnostic systems is based on a small number of studies which were recruited under very strict methodological criteria. It is too early to draw a firm conclusion as to the effectiveness of the broad based diagnostic CDSS in clinical practice. Other researchers have felt that a broader view of acceptable evaluation is warranted, especially in the earlier stage of development (Berner, Webster, & Shugerman 1994), (Miller 1986). Assessment of most diagnostic systems occurs in a non-clinical setting in the early phases, such as measuring accuracy against a gold standard, reliability, and acceptability. The results of evaluation on accuracy of diagnosis systems is promising (Feldman & Barnett 1991), (Lau & Warner 1992). The recent research of QMR on clinicians' performance from different institutes has shown that clinicians' diagnostic performance can be strongly influenced by the quality of information the CDSS produces and the type of case the system is used too (Berner et al. 1999). Moreover, there is a larger effect for students suggesting a possible educational role for these systems (Friedman, Elstein, Wolf, Murphy,

Franz, Heckerling, Fine, Miller, & Abraham 1999). Good controlled clinical trials are obviously needed to evaluate the efficacy of systems to the patient outcome in clinical practice.

5.4.4. The Application of CDSS in Dentistry

Dentistry employs computer technology mostly in oral radiology and with dental imaging techniques exclusively on the equipments and supported softwares. A recent review of using computers in dentistry has shown that the technology is advanced in both dental radiographic hardware and corresponding software (Umar 2002). One example is a radiographic software which uses the application of a 4-Gray level isodensity filter to depict the soft tissue profile of a patient in a cephalometric image. That article also emphasised advances in dental imaging hardware and software. Examples of hardware are three-dimensional imaging using stereolithographic methods to build three-dimensional plastic models, a method to produce three-dimensional images from a series of two-dimensional images named 'tuned aperture computed tomography (TACT)', and a method to prevent distortion and artifacts in computed tomography caused by metallic restorations named 3DX multi-image micro computed tomography. Image analysis software to assist interpretation has also been developed such as automatic densitometric image analysis, named CADIA, in periodontal radiographs, digital subtraction methods to quantify alveolar bone density, and the virtual articulator for the analysis of dysfunction and the dysmorphology of dental occlusion.

In contrast to the progress in hardware and software in oral radiology and dental imaging, the development of decision support systems which solves clinical problems for dental patients is substantially less and is less developed than in medicine. A large medical literature on CDSS has been documented in databases, though both medicine and dentistry systems have been developed since the 1970s. Unlike medicine, CDSS in dentistry focuses on diagnostic systems and advice in treatment planning. The need to integrate more dental informatics including CDSS have been raised in the literature for the past decade (Abbey 1991), (Stheeman, van der Stelt, & Mileman 1992), (White 1996), (Schleyer & Spallek 2001), (Umar 2002). The reviewed literature reveals that domains tackled in dental CDSS included oral medicine, orofacial pain, oral

pathology, oral radiology, oral and maxillofacial surgery, endodontics, orthodontics, prosthodontics, implantology, caries prediction, and oral cancer risk prediction, with example of diagnostic systems summarised in Table 5.1. Most of the systems have not been implemented in clinical practice. All of the systems are stand alone. Other studies are not CDSS but have employed computerised techniques to predict or diagnose including caries prediction using Classification And Regression Tree (CART) techniques (Stewart & Stamm 1991), screening patients at risk of oral cancer and pre-cancer using neural network to analyse patients' history data (Speight et al. 1995), the diagnosis of dental pain (Clifford, Kennedy, & Lamey 1998a) and orofacial pain (Clifford, Kennedy, & Lamey 1998b) using CART techniques, the detection of malignant cells from an oral brush biopsy (OralCDx) using a neural network to analyse the imaging of cell morphology (Sciubba 1999), compared three computerised techniques (decision tree algorithm, unsupervised clustering of Kohonen network and statistic method of point distribution model) on classification of facial deformity in orthodontic patients (Hammond et al. 2001). Other studies are the logical algorithms for the diagnosis and treatment planning of orofacial pain including a logical decision tree flow chart for treatment of facial arthromyalgia (Clark 1980), a logical flow chart for the differentiated trigeminal neuralgia and pretrigeminal neuralgia (Merrill & Graff-Radford 1992).

Table 5-1: List of publications of CDSS for the diagnosis in dentistry.

Reference	Knowledge Domain	Purpose	Clinical Reasoning
Leonard and co-workers (1973, 1974)	Orofacial Pain	Diagnosis and treatment of pain in and around the TMJ	Linear pattern-recognition and Markovian decision algorithm
Hyman and Doblecki (1983)	Endodontics	Diagnosis of pulpal disease and suggest endodontic treatment	Bayes' s theorem
Matsumura (1986)	Orofacial Pain	Diagnosis of headache and facial pain	Rule-based
Ralls et al. (1986)	Dental emergency	Diagnosis and treatment of dental emergencies and soft-tissue lesions	Decision tree
White (1989)	Oral radiology	Differential diagnosis of intrabony lesions in the jaws by using radiographic and clinical features, (ORAD)	Bayes' s theorem
Hubar et al. (1990)	Oral radiology	Computerized Radiographic Differential Diagnostic system (COMRADD), diagnosis of intraosseous lesions and soft tissue lesion by using dental radiographic and clinical information.	weighted and non-weighted pattern-recognition algorithm
Monteith (1991)	Endodontics	Diagnosis of pulpal pain	Bayes' s theorem

Reference	Knowledge Domain	Purpose	Clinical Reasoning
Firriolo and Wang (1993)	Endodontics	Diagnosis of pulpal pain Computerised Expert System for the Diagnosis of Pulpal Pathosis, (COMENDEX)	Rule-based and Bayes's theorem
Stheeman et al. (1995)	Oral radiology	Diagnosis of pathology from radiographs	Linear diagnostic model using imaging reference
Firriolo and Levy (1996)	Oral pathology	Diagnosis of histopathology of salivary gland neoplasms	Rule-based (forward chaining and backward chaining), linear pattern recognition, and Bayes' s theorem
Hammond and Freer (1997)	Orthodontics	Diagnosis and treatment planning	Case-based reasoning
Robertson and Noren (2001)	Dental trauma	Diagnosis, and treatment of traumatised teeth	Decision tree and rule-based
Yap et al. (2001)	Orofacial pain	Pain and disability classification according to Axis II of RDC/TMD (Research Diagnosis Criteria / Temporomandibular disorders)	Microsoft C++ programming

5.4.5. The Diagnostic CDSS in Dentistry

In this section, only CDSS in the diagnosis of orofacial pain and pulpal pain are reviewed and discussed. Other algorithms for the diagnosis are also reviewed though they are not implemented in computerised format.

The first computerised decision support system for diagnostic uses in dentistry was produced by Leonard et al. (1973). The system aims to give the differential diagnosis and treatment plan of orofacial pain to users. This system used a linear pattern recognition method to diagnose the disease. Pattern recognition uses statistical techniques to classify a set of objects into a number of distinct classes (Gelsema 1997). Clinical data were collected from the patient using a paper-based checklist divided into 3 parts i.e. pain history, examination, and laboratory test results. The checklist provided a head and neck diagram to allocate the location of pain and tenderness; 144 clinical data items were collected. All clinical data items are coded and the clinician identifies their presence or absence. Then the patients who present with pain in the head and neck are classified into 20 possible diagnoses as shown in Table 5-2.

Table 5-2: Classification of diagnoses of pain in the head and neck in Leonard's CDSS (Leonard, Robert, Fast, & Mahan 1973)

Patient state classifications
<ol style="list-style-type: none"> 1. Fracture condyle or fossa 2. Neuropathy 3. TMJ arthridity: any pathosis of the TMJ 4. Myopathy: any pathosis of a muscle 5. Craniopathy: any disease of skull, including stroke, tumour of the brain and brain stem, or headache 6. Nasal or sinus pathoses 7. Drug effect: therapeutic and side effect of drugs 8. Lymphadenopathy: any pathosis of lymphatic system 9. Dental pathosis 10. Periodontal pathosis 11. Vascular changes: including thrombosis, temporal arteritis, periodic migrainous neuralgia, flushing of the skin, wheal formation. 12. MPD – malocclusion 13. MPD – presence of slide from retruded contact to maximum intercuspatation 14. MPD – psychoneurosis: pain associated with emotional disorder resulting in inappropriate behaviour or discomfort, or both

Patient state classifications
15. MPD – developmental abnormalities 16. MPD – haematoma of the masticatory muscle 17. MPD – bruxism 18. MPD – reflex protective muscular contracture 19. MPD – loss of posterior occlusion 20. MPD – malpositioning of the condyle

MPD : Myofascial Pain Disorder

The diagnostic model used linear discrimination to classify the patient into a diagnostic group. The system was trained to assign “weight” parameters for classifying the patients with training data from two sources. First, artificial case scenarios were constructed as typical representatives of each diagnosis. Second, the medical records were reviewed and classified. The author did not describe the method of assigning weight to the parameter. The system was then used to classify the test data. The accuracy of diagnosis was 78% calculated from the proportion of correct classifications. The system has not been validated in a clinical setting.

Leonard’s experiment (Leonard et al 1973) shows the potential of a mathematical model for the diagnosis of orofacial pain. However, the system was not developed beyond a research prototype for a number of reasons. Firstly, the checklist is long and takes considerable time to complete and the input data needs manual typing into the system. Secondly, it is a stand alone system and generates a diagnosis without any explanation of the underlying reasoning. Thirdly, the classification of diagnosis is not widely accepted. Fourthly, it may be too advanced for those days and may not received attention from the dental community. Fifthly, the computer hardware may be expensive and slowly operating.

Hyman and Doblecki (1983) devised a system to aid in the diagnosis of pulpally involved teeth. This is a specific domain of knowledge with served diagnostic possibilities:

- healthy tooth,
- reversible pulpitis,
- irreversible pulpitis, and

- pulp necrosis.

The system was developed in the BASIC computer language. It used Bayes's theorem which employs conditional probabilities to evaluate the pulpal status of a tooth. To use the system, the examining dentist first obtains the patient's history and then completes a clinical examination. The program produces a list of diagnoses, each with an associated probability based on 19 symptoms and simple test results. The prior probabilities of symptoms/signs were obtained from a retrospective survey of medical records. A test on 38 patients showed an agreement between the system and a clinician between 78% and 100% on a variety of diagnostic decisions. The authors suggested that the system is more appropriate for use by a general dental practitioner as a consultation program for a second opinion.

The interesting characteristic of this system is that it required minimal data input and its accuracy was very high. Although the test result is favourable, it should be noted that this system considered only pulpal disease and the diagnosis test problems used were simpler than those found in a clinical setting.

Ralls et al. (1986) developed a system for the diagnosis of dental trauma. The program, written in BASIC used a decision-tree flow chart approach. A pattern classifier in the form of IF-THEN rules, two for each diagnosis, is used to complete a diagnosis. One formula is precise and gives a diagnosis with a confidence value of "probable". The other is less precise and gives a diagnosis with a confidence value of "possible". More than one diagnosis can be computed with a confidence value. This system also offers a treatment plan for each diagnostic condition. It was tested on actual patients by a dental assistant (nurse), and the results were compared to those achieved by dentists. The accuracy of the system was estimated to be between 87% and 95% compared to the dentist's diagnoses.

Matsumura (1986) developed RHINOS, a diagnostic system for headache and facial pain based on rule-based reasoning. RHINOS gives a differential diagnosis for 40 diseases which cause headache and/or facial pain. It was derived from a classification of pain established by a committee of six American specialists led by the Ad Hoc Committee on Classification of Headache (AHCCH) (Ad hoc Committee on Classification of Headache 1962). The diagnostic

model in RHINOS employs a four rules structure to represent relationships between symptoms, signs, and disease categories.

The first covers exclusive rules of the form;

If the patient has disease D, then he must have symptoms S_1, S_2, \dots, S_n

The second is inclusive;

If the patient has symptoms S_1, S_2, \dots, S_n , then he probably has disease D with a slightly chance of having other disease.

The third is associate;

If the patient has symptoms S_1, S_2, \dots, S_n , then he may use disease D with a certain probability of having another disease.

The fourth comprises disease image rules;

If the patient has disease D, he may have symptoms S_1, S_2, \dots, S_n

Through the integration of these four types of rules, RHINOS gives the advice. The knowledge of the system was acquired from an expert in headache and facial pain. Users answer 16 questions and identify the tender spot as predefined on facial representation. The example of the questionnaire is shown in Figure 5-1.

1. Age:

1) 0-5 2) 6-13 3) 14-25 4) 35-50 5) 26-34 6) 51-

2. Sex:

1) male 2) female

3. Pain location:

1) half of head	2) whole brain
3) frontal	4) frontal sinus region
5) temporal	6) deep temporal
7) parietal	8) parietocentral
9) occipital	10) suboccipital
11) nuchal region	12) shoulder
13) half of the face	14) deep of the face
15) eye region	16) deep of the eye
17) cheek	18) lateral aspect of the cheek
19) ear region	20) deep of the ear
21) mandible	22) deep of the nose

4. Which side:

1) right 2) left 3) both

5. Degree:

1) slight 2) hard

6. Nature of pain:

- | | |
|-------------------|--------------------|
| 1) throbbing pain | 2) continuous pain |
| 3) busting pain | 4) radiation pain |
| 5) numbness | 6) others |

7. Severity of pain:

- | | |
|------------------------------|-----------------------|
| 1) able to continue the work | 2) interrupt the work |
| 3) lie down | 4) be in agony |

8. History since onset:

- | | |
|-------------------------|--------------------------|
| 1) sudden death | 2) steeping aggravation |
| 3) acute progressive | 4) subacute progressive |
| 5) chronic progressive | 6) paroxysmal repetitive |
| 7) wavy continuous | 8) transient |
| 9) transient repetitive | |

9. Frequency of the paroxysm:

- | | |
|--------------------------|-------------------------|
| 1) more than twice a day | 2) twice a day |
| 3) once a day | 4) less than once a day |

10. Duration of the paroxysm:

- | | |
|------------------------|-------------------------|
| 1) more than 5 days | 2) more than 48 hours |
| 3) more than 12 hours | 4) more than 6 hours |
| 5) more than 2 hours | 6) more than 20 minutes |
| 7) more than 3 minutes | 8) less than 3 minutes |

11. Prodromal syndrome:

- | | |
|--------------------------|--------------------------------------|
| 1) scintillation scotoma | 2) wavy oscillation of landscape |
| 3) being hungry | 4) shoulder nuchal muscle stiff feel |
| 5) others | 6) none |

12. Concurrent neurological sign during paroxysm:

- | | |
|---|--------------------|
| 1) myosis | 2) mydriasis |
| 3) ptosis | 4) ophthalmoplegia |
| 5) hemiparesis | 6) monoparesis |
| 7) paresthesia or hypoesthesia or hyperesthesia | |
| 8) homonymous hemianopia | 9) aphasia |
| 10) others | 11) none |

13. Interval of paroxysm:

- | | |
|-----------------|----------------|
| 1) asymptomatic | 2) symptomatic |
|-----------------|----------------|

14. State of sleeping:

- | | |
|------------------------------------|-----------------------------|
| 1) difficult to get to sleep | 2) midnight awaking |
| 3) difficult to get to sleep again | 4) have many dreams |
| 5) awake too early | 6) fatigue after getting up |
| 7) annoying after getting up | 8) none of them |

15. Family history:

- | |
|--|
| 1) positive hereditary predominancy about headache |
| 2) nothing particular |

16. Ratio of present severity of pain to past severest period:

- | | |
|-------------------|--------------------|
| 1) 10/10 | 2) more than 5/10 |
| 3) more than 0/10 | 4) completely 0/10 |

Figure 5-1: The history questionnaire of RHINOS (Matsumura 1986).

After acquiring answers to the 16 questions, RHINOS applied the diagnostic rules and produce a list of differential diagnoses with satisfactory indices and

reasoning for its diagnosis. The system was tested on 50 patients. The diagnoses coincided with that of the expert in 41 cases and showed only slight discordance in 8. The system directly interacted with users on screen. The author was cautious of input data error and suggested using objective words, graphics, and checking system for data entry.

Monteith (1991) proposed a system for the diagnosis of pulp-related pain. This adopted the classification of the tooth condition and the same set of clinical data input as was used by Hymen and Doblecki. The system was developed using the language Turbo-Prolog and once more employed Bayes' Theorem. The priori probabilities were gained from a literature search. The clinician enters data directly by answering a questionnaire shown on the computer screen. The interface is simple and user friendly. However, it was not validated either in the laboratory or in a clinical setting.

Merill and Graff-Radford (1992) proposed a decision tree algorithm for diagnosing facial pain, specifically to differentiate trigeminal neuralgia and pretrigeminal neuralgia from toothache, other facial neuralgias, headaches, myofascial pain, and other TMJ disorders. The diagnostic algorithm is based primarily on the analysis of clinical data including clinical feature and treatment outcomes obtained from a retrospective study of medical records of a group of 61 patients who were diagnosed as having trigeminal neuralgia. No probabilities were included for advocating one decision versus another at any node in the decision tree, which received criticism of an unreliable and invalid clinical outcome from other researchers (Mohl & Ohrbach 1992). The clinical reasoning of the diagnosis was not implemented in a computerised system and was not evaluated in a laboratory or clinical setting.

Firriolo and Wang (1993) developed COMENDEX, a computerised expert system for the diagnosis of pulpal pathoses, classified as;

- normal pulp,
- reversible pulpitis,
- reversible pulpitis as a result of hyperocclusion,
- irreversible pulpitis; necrotic pulpitis, and
- necrosis/infection as a result of endodontic failure.

COMENDEX is a hybrid system, with both Bayesian and a rule-based inference. It was developed using a commercial expert system named EXSYS Professional, V.3.0.2 and was written in TurboPascal V.5.5. The domain knowledge was obtained from an expert, then translated into a logical sequence of observations, actions, and conclusions that parallel the expert's diagnostic process. The input data were collected from the patient through a paper checklist and then entered into the system. The history checklist is shown here in Figure 5–2.

1. Please indicate the degree of pain the patient is experiencing:

- ☐ none
- ☐ mild – (aware of pain but it does not interfere with normal activities).
- ☐ moderate – (pain sometimes makes work and sleep difficult).
- ☐ severe – (pain is so severe, the patient is unable to sleep or work).

2. Select those statements(s) from the patient's history which apply:

- ☐ patient experiences spontaneous pain.
- ☐ pain with hot.
- ☐ pain with cold.
 - ☐ short, mild transient sensation.
 - ☐ prolonged sensation, after removal of stimulus.
 - ☐ unknown duration.
- ☐ pain upon chewing.
- ☐ pain causes loss of sleep or awakens patient.
- ☐ none of these symptoms are present.

3. Select all positive findings from clinical exam:

- ☐ percussion sensitivity.
- ☐ intraoral or extraoral swelling.
- ☐ sinus tract present.
- ☐ apex, tender to palpation.
- ☐ clinical decay or caries.
- ☐ previous restoration performed.
- ☐ tooth is in hyperocclusion.
- ☐ previous endodontic therapy performed.
- ☐ cold testing
 - ☐ prolonged sensation.
 - ☐ transient sensation.
 - ☐ no response.
- ☐ all clinical findings normal.

4. Indicate radiographic findings:

- ☐ normal OR none of the findings below.
- ☐ widened PDL.
- ☐ periapical radiolucency.
- ☐ carious exposure of pulp or decay within 1-2 mm. of pulpal tissue.
- ☐ not done.

5. Indicate results of EPT:

- ☐ positive.
- ☐ negative.
- ☐ not done.

Figure 5-2: The history questionnaire of COMENDEX (Firriolo & Wang 1993).

The criteria for diagnosis and the methods used to compute confidence values are not described in the article. The resulting diagnosis was shown as a ranked differential diagnosis, with confidence values for each diagnosis. The systems' diagnosis was validated by reference to a panel of judges who verify the correctness of the COMENDEX's diagnosis against human diagnosis. Although a rule-based reasoning method was claimed to be used, the system did not provide any explanatory function or critique for its diagnosis.

Clifford et al. (1998) induced a decision tree algorithm for the diagnosis of dental pain (Clifford, Kennedy, & Lamey 1998a) and orofacial pain (Clifford, Kennedy, & Lamey 1998b) using a technique of Classification And Regression Tree (CART) (Breiman et al. 1984). However, this induced decision tree algorithm was not implemented in CDSS and was not evaluated in the clinical setting.

Yap et al. (2001) developed a computerised program for the diagnosis of pain-related disability and psychological status of TMD patients based on Axis II of the research diagnostic criteria for temporomandibular disorders (RDC/TMD) (Dworkin & LeResche 1992). This paper-based questionnaire of RDC/TMD was transferred into a computerised one. Clinicians directly entered the patient's data into the computer via a computer interface. The grade chronic pain severity score, jaw disability score, and psychological score based on revised symptom check list 90 (SCL-90-R) are calculated. The patients are classified according to these three scores into 5 categories as follows

- no TMD pain,
- low disability / low intensity pain,
- high disability / high intensity pain,
- high disability / moderately limiting, and
- high disability / severely limiting,

accompanied by the psychological status of depression/vegetative and somatization scales. The system is not a true diagnostic CDSS. It is rather a computerised program which can calculate patient's scores and classify patients into categories according to cut-off scores of pain severity and jaw disability of the RDC/TMD. The system was tested on a pilot group of 40 patients in clinical setting without clearly specified objectives of outcome.

In conclusion the previous diagnostic CDSSs for dental and orofacial pain have the characteristics of the so called “Greek Oracle” and acts as stand alone, which required clinical data input transferred from a check list by a clinician or clerk. The decision support system did not integrate to the clinician routine task such as a medical/dental record for collecting patient data for management. As it required extra work for the clinician, it has never been used in a clinical setting.

5.5. The Basic Structure of Decision Support Systems

The generic structure of DSSs can be divided into 4 main components as below:

- The knowledge base
- The inference engine
- The user interface and database

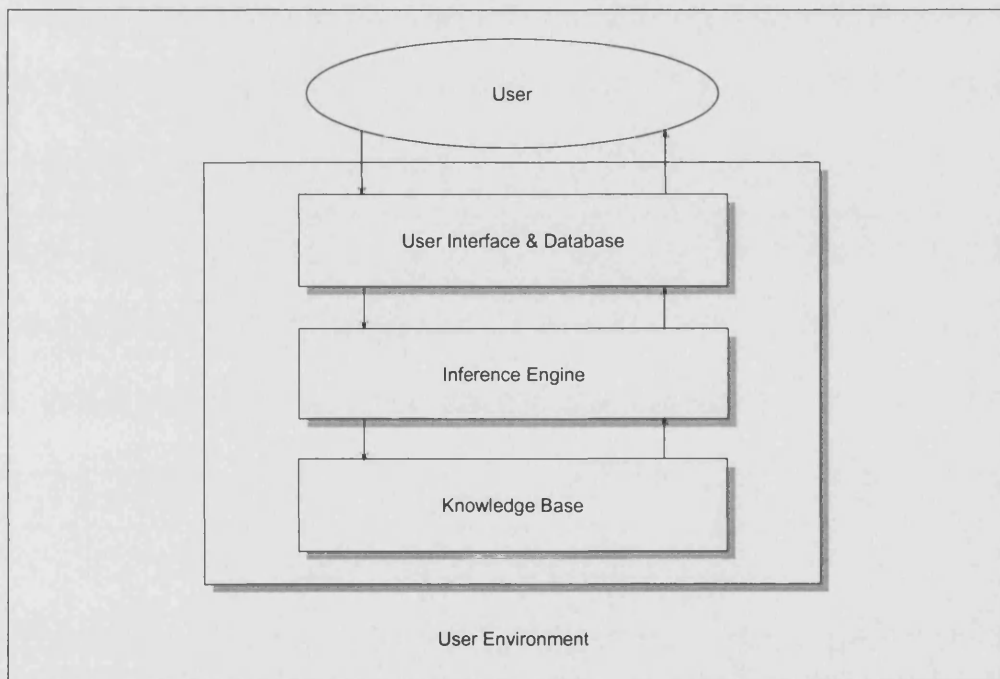


Figure 5-3: The Decision Support System architecture modified from (Marakas 1999). [re-drawn]

5.5.1. The Knowledge Base

The knowledge base of a DSS contains an explicit body of knowledge appropriate to solve the problem of a specific domain. The accuracy and completeness of the knowledge is a key factor for the successful DSS. The type

of knowledge can be definitions and relationships of an object, for example, the classification of a diagnosis which embraces the clinical features and their definitions, relationships among clinical features. Other types of knowledge are problem-solving skill, constraints, heuristics and uncertainties. The method for collecting the knowledge from the domain expert is called knowledge acquisition. This is performed by the person called a knowledge engineer.

5.5.2. The Inference Engine

The inference engine is the component used for manipulating the knowledge for a specific task. It activates all the domain knowledge that has been gathered and performs reasoning by applying its specific strategy to solve problems.

5.5.3. The User Interface and Database

An interface is a component of a system that is specifically intended to allow the user to communicate and interact with the system. In general, most computer programs provide the way to communicate with users. The DSS interface is more interactive to achieve its responsibility for interaction and communication. It must deal with factors concerning human interaction, accessibility, ease of use, user skill level, error capture and reporting, and issues relating to documentation. The success or failure of a DSS can often be attributed to its interface. The database provides the storage for storing and retrieving data as required for specific proposes. For example, to generate a diagnosis list, the manipulating protocol in the inference engine requires pain history data taken from the database and evaluated against the knowledge base.

The components of a Diagnostic Clinical Decision Support System can therefore be characterised specifically as:

1. Knowledge; It has to be medical knowledge in order to support a clinical diagnosis.
2. A problem-solving component that applies the knowledge to a specific clinical situation.
3. Data; clinical data such as patient history data, laboratory data, electronic biosignals (e.g. ECG), radiographic images.
4. Assistance for the diagnostic process producing; output such as a differential diagnosis.

5. Database and user interface that allows interaction and communication between a user and the system and storing and retrieving patient data such as a medical record system.

5.6. Knowledge Acquisition: A Bottle Neck of the CDSS

5.6.1. General Consideration

Knowledge acquisition involves obtaining knowledge from a human expert and using it to build a decision support system. According to Jackson (1999), Buchanan et al. (Buchanan et al. 1983) define knowledge acquisition as follows:

'Knowledge acquisition is the transfer and transformation of potential problem-solving expertise from some knowledge source to a program.'

Knowledge acquisition involves eliciting data from the expert, interpretation of this information to deduce the underlying knowledge and using it appropriately to construct and explain a line of reasoning. The method to obtain knowledge is usually a series of intensive interviews. Initially, informal discussions are used to gather preliminary information. These are followed by more formal, structured interviews. It is seen as a bottleneck problem and a laborious part of building decision support systems.

Because the traditional method is laborious, this has led some researchers to try to automate the process of knowledge acquisition. There are 2 ways to automate the process of knowledge acquisition. The first one uses knowledge acquisition software for eliciting knowledge interactively from human experts. Examples of knowledge acquisition systems are

- OPAL – an interactive graphical system used in the cancer management domain.
- PROTÉGÉ-I - a high-level knowledge acquisition system for clinical trials. It is a domain independent and can be used for other related knowledge acquisition tasks for example a clinical trial for cancer treatment, and for antihypertensive drugs for which the same problem-solving method was appropriated.

The second exploits the subfield of Artificial Intelligence known as “machine learning” for automatically generating knowledge structures. The machine can learn from a training set, and constructs an algorithm for solving new problems.

Examples of applications that use machine learning include predicting risk factors for oral cancer (Speight, Elliott, Jullien, Downer, & Zakzrewska 1995) (Brickley, Cowpe, & Shepherd 1996), decision making for removal wisdom teeth (Brickley & Shepherd 1996), diagnosis of low back pain (Bishop et al. 1997), and diagnosis of breast cancer (Floyd et al. 1994). The methods for such machine learning are varied and often produce decision-making algorithms different from human expertise. Many users reject machine learning algorithms because they cannot show the resulting decision making process in a transparent fashion. The study of the knowledge pattern induction using machine learning has been included in Chapter 6. In this section, the knowledge acquisition theory will be examined. The resulting knowledge modelling for the diagnosis of CIFP is illustrated and discussed.

5.6.2. The Concept of Knowledge

5.6.2.1. Definition

The terms data, information, and knowledge are similar and have a common-sense meaning, but quite often their definition is not well understood. As knowledge acquisition is to transfer and transform the knowledge from the expert to an explicit representative format of knowledge, we must understand what we are working with and what exactly “knowledge” is.

- **Data**

Facts, measurements, or observations can be specified as data. Examples of data are 37.6, 120/80, pain, red, hot, swelling etc. Items of data have no meaning on their own. Their validity and effectiveness are also determined by their accuracy.

- **Information**

Data is organised in such a way that is useful and relevant of what we are interested. Examples of information are body temperature 37.6°C, blood pressure 120/80 mmHg., the swollen gum with pain.

- **Knowledge**

Knowledge is the application of a combination of intuitive, cognitive analysis, rules, procedures and information to solve the problem and make

the decision. Knowledge is dynamic and changes with time depending on the situation. Knowledge develops as we discover new things.

5.6.2.2. Types of Knowledge

Higgs and Titchen (2000) have classified knowledge into 3 types namely propositional knowledge, professional craft knowledge, and personal knowledge. The latter two are derived from non-propositional knowledge (or 'know how'). They are overlapping and interactive.

1. Propositional knowledge. This refers to theoretical or research knowledge which has been ratified or supported by the field. It encompasses knowledge from literature, textbooks and the presentation of abstracts, logical and formal relationship of concepts, and causal relationship between events.
2. Professional craft knowledge. This incorporates 'know how' and tacit knowledge of the professional. Clinicians use practical or procedural skill (or 'know how') in their professional practice for caring for patients. It is noted that clinicians use intuitive knowledge for making decision when faced with incomplete or ambiguous data.
3. Personal knowledge. This is a category of knowledge with particular relevance to clinical reasoning based on an individual personal frame of reference. Higgs and Titchen (2000) elaborated the meaning of an individual frame of reference as;

'The term consciousness refers to the primary frames of meaning we use to interpret our own life and the world. The individual's behaviour is highly influenced by his/her frames of reference. Within these frames of reference, scientific knowledge and professional knowledge are translated into decisions for practice which are influenced by the individual's convictions and judgements about the worth of this knowledge and its relevance to the current situation. New knowledge is compared with the individual's existing system of beliefs and values. If new knowledge or ideas are incongruent with their belief system, individuals may reject the new information.'

Medical knowledge is rich in all three types of knowledge. However, if the information is incomplete and ambiguous, clinicians are likely to use experience and intuition to make decisions. Medical knowledge is derived from two sources: from clinical experts and from the published medical literature, the latter often using data from critical review or meta-analysis of particular domains.

5.6.3. The Stages of Knowledge Acquisition

In the Introduction to Expert Systems, Jackson (1999) used the knowledge acquisition model of Hayes-Roth (1985) to generally illustrate how the knowledge from experts transforms into structure representative knowledge. The transformation of knowledge has been decomposed into 5 general stages as in Figure 5–4.

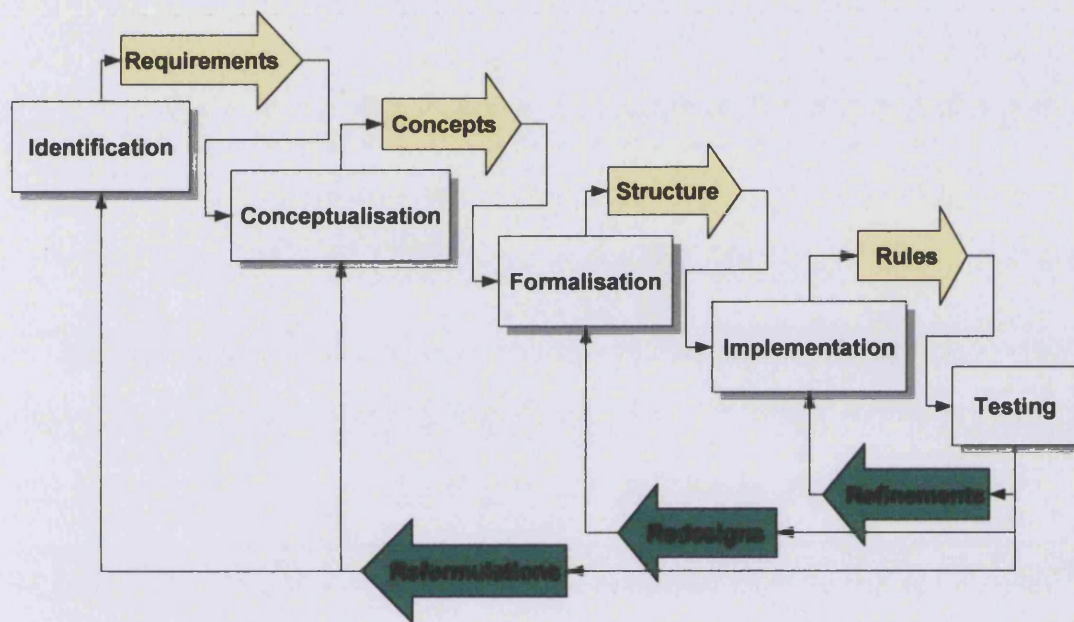


Figure 5–4: Stages of knowledge acquisition (modified from Jackson 1999).

- Identification

Identifies the problem characteristics including the data that the system will work with and the criteria that solution must meet. The resources available for the project including expertise, manpower, time constraints, computing facilities, and money. Then, requirements are established to be input for the next stage.

- Conceptualisation

Find out the key concepts and the relationship between them to represent knowledge.

- Formalisation

The concepts are organised to establish structured knowledge. There are 2 concerns for structuring knowledge; nature of the search space (steps for reaching the solutions) and information uncertainty.

- Implementation

Rules, frames are formulated to represent the knowledge. This will turn the rules into runnable programming. The programming regime must be designed.

- Testing

Rules that organise knowledge are validated. Preliminary tests can be performed with test cases in laboratory. The common mistakes are rules which are missing, incomplete, incorrect, while competition between related rules can also causes problem.

This process is recursive in nature. Once an initial cycle is complete, series of refinements, redesigns, and reformulations are required until all of the requirements and elements of knowledge have been correctly identified and correctly modelled. This recursive process can be lengthy and tedious and requires constant attention to detail on the part of the knowledge. However, this process is necessary to ensure that the domain knowledge is captured.

5.6.4. Knowledge Acquisition Techniques

There are a number of knowledge acquisition techniques in the literature for example; interviewing techniques, protocol analysis, repertory grids, card sort, and questionnaires. The most common techniques are examined here.

5.6.4.1. Interviewing Techniques

The interview is frequently used to obtain knowledge from experts. Although this technique seems to be straightforward and easy to perform, it is thought to be an art because it is a skill and requires significant preparation to achieve useful results. Interview is usually classified into structured or unstructured.

- Unstructured Interviews

This approach is usually used in the early stage of knowledge acquisition. It gives an opportunity to explore the knowledge domain and allows the

knowledge engineer to prepare for a more detailed analysis. An unstructured interview is similar to normal conversation.

- **Structured Interviews**

This approach requires significant preparation, in terms of the topics to be discussed and the sequence and construction of questions to be used. Properly performed structured interviews can elicit a detailed insight into an expert's knowledge and can generate clarifications, explanations, justifications, and consequences of each case to be organised into a well defined knowledge structure for solving relevant problems.

5.6.4.2. Verbal Protocol Analysis

This method is designed specifically to capture knowledge that is implicitly used by experts when they solve a particular problem. The knowledge engineer needs to retrieve and structure it in a manner that is usable by a computer. This is one of the most difficult issues in knowledge acquisition. A protocol is a record or some form of documentation of the step-by-step information processing and decision-making behaviour employed by an expert during a specific task. There are several approaches to collecting the protocol including retrospective, introspective, interpretative, and concurrent. The most popular and useful one is concurrent or 'thinking aloud'. A concurrent protocol is collected by asking the expert to think aloud, or verbalise, his/her thoughts while simultaneously performing a task. It is believed that the verbal protocol analysis can tap directly into the detailed process information contained in the mind of the expert and can closely reflect the true cognitive processes used.

5.7. Knowledge Representation

Knowledge representation involves a systematic way to codify what an expert knows about some domain (Jackson 1999). Knowledge representation is defined as a formal description of knowledge in terms of, for example, decision trees, Bayesian statistics, production rules, or frames (Helder, van Bommel, & Musen 1997). Jackson (1999) elaborated knowledge representation as:

'It is concerned with the ways in which information might be stored and associated in the human brain, usually from a logical, rather than a biological, perspective. In other words, it is not typically concerned with the physical

details of how knowledge is encoded, but rather with what the overall conceptual scheme might look like.”

The following are the descriptions of Bayes' s theorem, production rules, and decision trees.

5.7.1. Bayes's Theorem

Bayes's theorem or Bayes's Rule is a probabilistic approach proposed by an 18th century English reverend from Tunbridge Wells, Thomas Bayes (1702-1761). This provides a method of dealing with uncertainty in decision making. Bayes's theorem is a formula that shows how existing beliefs, formally expressed in probability distributions, are changed by new information. This theorem serves to define the concept of the conditional probability, which is often used in medicine. In mathematical notation, this conditional probability is written as:

$$P(d|s)$$

The conditional probability of d given s is simply the probability that d occurs if s occurs, for example the probability that a patient is suffering form disease d if she or he complains of symptom s . The simplest form of Bayes's theorem is expressed as:

$$P(d|s) = \frac{P(s|d)P(d)}{P(s)}$$

$P(d)$ is the prior probability of d , that is, the probability prior to the discovery of s ;

$P(d|s)$ is the posterior probability, that is, the probability of d given the occurrence of s ;

$P(s|d)$ is the probability of a symptom occurring if a particular disease occurs;

$P(s)$ is a probability of a particular symptom occurring.

Bayes's theorem allows us to compute the posterior probability $P(d|s)$ of a disease d , given its prior probability $P(d)$ and knowledge about the conditional probability $P(s|d)$ that symptoms occur in a given disease. For example, the likelihood of sinusitis for a patient with pain when bending down is written as:

$$P(\text{sinusitis} | \text{pain when bending})$$

This is read as “the probability of sinusitis given the presence of pain when bending down”.

$$P(\text{pain when bending} \mid \text{sinusitis})$$

is simply the probability of pain when bending down given the presence of sinusitis. This probability could be found by studying a series of patients with confirmed sinusitis and computing the percentage who present with pain when bending down. By using Bayes’s theorem, we have

$$P(\text{sinusitis} \mid \text{pain when bending}) = \frac{P(\text{sinusitis}) P(\text{pain when bending} \mid \text{sinusitis})}{P(\text{pain when bending})}$$

To solve the equation, we not only need $P(\text{pain when bending} \mid \text{sinusitis})$, but also need $P(\text{sinusitis})$ – the probability of sinusitis independent of any given symptoms – and $P(\text{pain when bending})$ – the probability to have pain at the face independent of any particular disease. As was mention earlier, this two independent probabilities are called prior probabilities, because they are the probabilities prior to the consideration of other factors. The disadvantages of probability theory are its assumption of independent of symptoms which in reality many symptoms are associated and computation intractable in case of dealing with dependencies among symptoms.

5.7.2. Production Rules

Production rule is another method which was widely used in decision support systems in the 1970's to 1980's. The name ‘Production Rules’ are called because rules are invoked one after another to produce chains of reasoning during problem solving. According to Musen (1997), Newell and Simon introduced the idea of using production rules to represent knowledge within computer systems. They hypothesised that the application of production rules is a necessary and sufficient property of human intelligence. It was claimed that there was a one-to-one correspondence between the production rules and the cognitive constructs that human experts used to solve problems. Human experts used heuristic cognition when describing how they solved problems. However, later research has demonstrated that there are discrepancies between the way they described their problem solving when they were asked and the way that they solve problems in practice. Moreover, the cognitive

psychological study has proposed other hypotheses (previously mentioned in section 5.3.2.1) to explain clinical reasoning. The rule-based system (the system which employed production rules) was employed in many early generation of decision support systems, for example MYCIN, Internist-I (a prototype of for many systems including QMR).

The format of production rules simply described as condition-action rules or situation-action rules. The rules encode the association between pattern of data presented to the system. Given some set of input data to the system, the match rules interpret and determine the outputs in order to solve the problem. The syntax of production rules can express in general form as:

$$P_1, \dots, P_m \rightarrow Q_1, \dots, Q_n$$

which we can read as:

If premises P_1 and ... P_m are true, then perform actions Q_1 and ... Q_n .

The premises are sometimes called 'conditions' or 'antecedents', and the actions 'conclusions' or 'consequences'. There are two strategies for driving the rules for problem solving; forward or backward driven.

1. Forward chaining systems

We can chain forward from conditions that we know to be true towards problem states which those conditions allow us to establish. This can be called forward reasoning or inductive reasoning because data analysis results in hypothesis generation or diagnosis. For example, consider the clinical rules:

IF	a patient has complaint of burning pain
AND	area is tongue or oral mucosa
AND	pain is relieved by food and drink
AND	oral mucosa is normal
AND	blood screen test for iron, vit B12, folic acid is normal
THEN	the patient has oral dysaesthesia.

2. Backward chaining systems

The principal of backward chaining is that it takes a course through the tree from the goal towards the elementary facts that sustain it. The system searches for properties which give sufficient proof to achieve the desired conclusion. The example from previous topic, the goal is to prove oral dysaesthesia then the system will search the properties of oral dysaesthesia

i.e. burning pain at tongue or oral mucosa, pain relieved with food and drink, oral mucosa is normal, and blood screen test for iron/vit B12/ folic acid is normal.

MYCIN (Shortliffe, Axline, & Buchanan 1973) is a famous prototype of the rule-based system. It was built in 1972 as collaboration between the medical and computer science communities at Stanford University. The purpose of MYCIN is to identify the bacteria(s) which cause a bacteremia and to assist a non-specialist physician with the appropriate treatment. There are about 400 production rules in MYCIN. These rules are stored in the system knowledge without explicit reference to the way in which they are interconnected. The general form of a set rules organised as:

If condition 1 and ... and condition m then conclusion 1 and ... and conclusion n

Although the efficacy is demonstrated, MYCIN has never been used in clinical setting. There are some reasons which may explain why it has never been used including:

- Its knowledge base is incomplete, though its 400 rules do not cover the domain of infectious disease.
- At that time, it would require considerable more power than most hospitals could afford.
- The interface is very poor and doctors do not like typing at the terminal.

5.7.3. Decision Trees (Hand-crafted Decision Trees or Flow Charts)

Decision trees are a way of structuring attribute-value information about concepts for the purposes of classification. It represents a particular way of breaking up a data set into classes or categories. The structure of the decision trees start from the root of the tree (high level node) which implicitly contains all the data to be classified. Intermediate nodes represent choice points, or test of attributes of the data, and a branch taken depending upon the value of the response which serves to further subdivide the data at that node. Leaf nodes represent the final class or result after categorisation or refinement. Decision trees that grow by the heuristic of experts are sometimes called hand-crafted decision trees or flow charts which is the main focus in this chapter. This decision tree is used specifically to represent experts' knowledge for problem

solving, especially in classification problems. Decision tree induction is a learning technique often used in the 'Machine Learning', a branch in Artificial Intelligence of Computer Science. The topic of machine learning and induced decision tree will be explained, and discussed in detail in Chapter 6 which dealing with the application of machine learning technique to the problem of diagnosis of CIFP.

The advantage of a decision tree is that it is very efficiently processed because only relevant input data are to be assessed. It also makes no assumption of conditional independence of attributes as would require by Bayes's theorem. Studies have shown that tree-based classification can compete with other methods. The disadvantage is that the decision-making process is very rigid; once we are on the wrong path of the tree, no return is possible, unless parallel trees are used. A decision tree is best at representing only a single subject. It is not obviously suited to build a complex causal representation.

5.8. Knowledge Modelling for the Diagnosis of CIFP

5.8.1. General Consideration

Knowledge modelling is the result of knowledge acquisition from the domain expert. It is a major challenge to construct any CDSS. It is this aspect of the system that distinguishes CDSS development from the development of conventional systems. Generally, knowledge in CDSS can be viewed into 2 main different roles in reasoning process; (1) domain knowledge, and (2) control knowledge. Domain knowledge is the knowledge used for the diagnosis whereas control knowledge is the knowledge used for the process of clinical problem-solving action. For example, in the diagnosis of pain complaint in the right mandibular area, the domain knowledge is

IF	dull and throbbing pain
AND	provoked by cold drinking
AND	tender tooth to percussion
THEN	possible diagnosis is pulpitis

and the control knowledge is

IF	complaint is diffuse pain
THEN	ask the user for aggravating and relieving factor

THEN inform the user to locate source of the pain by physical examination

The hand-crafted decision tree for the diagnosis of CFP is a minimal approach for which domain knowledge and control knowledge are not explicitly separated. The decision tree will lead users by proposing questions in a logical order for eliciting clinical data to reach a diagnosis. At the same time, it is capable of giving informative knowledge of the diagnosis. The acquired knowledge for the diagnosis of CFP is captured into 6 main decision trees based on areas which have pain. They are the decision trees of frontal, maxilla, mandible, TMJ & parietotemporal, alveolus & teeth, and oral mucosa. It is convenient for the expert to correlate conditions which characterise pain in the orofacial areas. It is also common for clinicians to logically solve clinical problems by starting from locations of complaints and then gathering other clinical information to deduce the diagnosis.

Diagnostic reasoning is a heuristic process acquired from the expert who has experience in orofacial pain. The hand-crafted decision tree is a parsimonious model using only high sensitivity and specificity of clinical signs and symptoms according to the expert opinion for the diagnosis. This subjective assumption of the expert is similar in some way to specify the prior probability in Bayes's theorem except that the actual number of probability has not included for calculation of the posterior probability. It attempts to be an easy uncomplicated guideline for use by general dental practitioners. The hand-crafted decision tree includes the most powerful criteria needed for clinical decision making rather than for research and epidemiological purposes. Therefore, radiography and haematology investigation are included for differential diagnosis and the hand-crafted decision tree attempts to include the most powerful criteria needed for clinical decision making.

The disadvantage is that during interviewing it does not cover all possible symptoms patients may encounter. However, employing the most reliable clinical data is adequate to detect all common conditions in the orofacial pain area. Knowledge for the differential diagnosis in some regions are extended to exclude the possibility of diagnoses other than CFP, into the level of fine grain knowledge. For example, in the maxillary region, the knowledge to diagnose

pulpal pain has led to a differential diagnosis by the investigation of the many possible causal agents that could cause pulpal exposure.

The hand-crafted decision tree for the diagnosis of CFP can be translated into diagnostic rules. In view of the process used to develop presentation of the knowledge, the hand-crafted decision tree and rules double check to achieve the pain diagnosis. The rules are in a classical form: the IF premises THEN conclusion. The premises are the hand-crafted decision nodes started from root node to the leaf node of the diagnosis. These rules enable diagnoses to be worked out. The system compares input data to premises (antecedent) of the diagnostic rules. If the input clinical data matches with the diagnosis rule, that rule will be triggered giving the diagnosis. This way of driving the rule is called forward chaining.

5.8.2. The Resulting Hand-crafted Decision Trees

The hand-crafted decision tree of 6 topographical areas including frontal, TMJ and parietotemporal, maxilla, mandible, teeth and alveolus, and the oral mucosa are presented in this section. In the maxilla, mandible, teeth and alveolar, and oral mucosa region the hand-crafted decision trees would be enormous if all the knowledge were to be put in a single presentation. Therefore, the hand-crafted decision trees have to be divided into eight small decision trees for maxilla and mandible, seven small decision trees for teeth and alveolus, and two small decision trees for oral mucosa.

Structure of the hand-crafted decision tree is a binary-Yes/No corresponding to the question node with a vertical arrangement leading to a leaf node of diagnosis. The nodes of the hand-crafted decision tree are arranged by starting from site, complaint of pain, quality of pain, provoking factor, clinical examination data, and radiography/haematology investigation, and diagnosis. Two distinct qualities of pain are used; (1) short sharp or stabbing or electric-like, and (2) dull ache or throbbing, to partition the hand-crafted decision tree since the type of pain is an important characteristic of any conditions presenting with pain. The simple dual classification into sharp or dull/throbbing may be challenged as being crude. However, classification based on other subjective description has not been validated for diagnostic purposes. Exceptions will exist such as the burning paresthesia of post herpetic neuralgia. However, here,

pathognomonic features such as the vesicular eruption are more important diagnostic criteria.

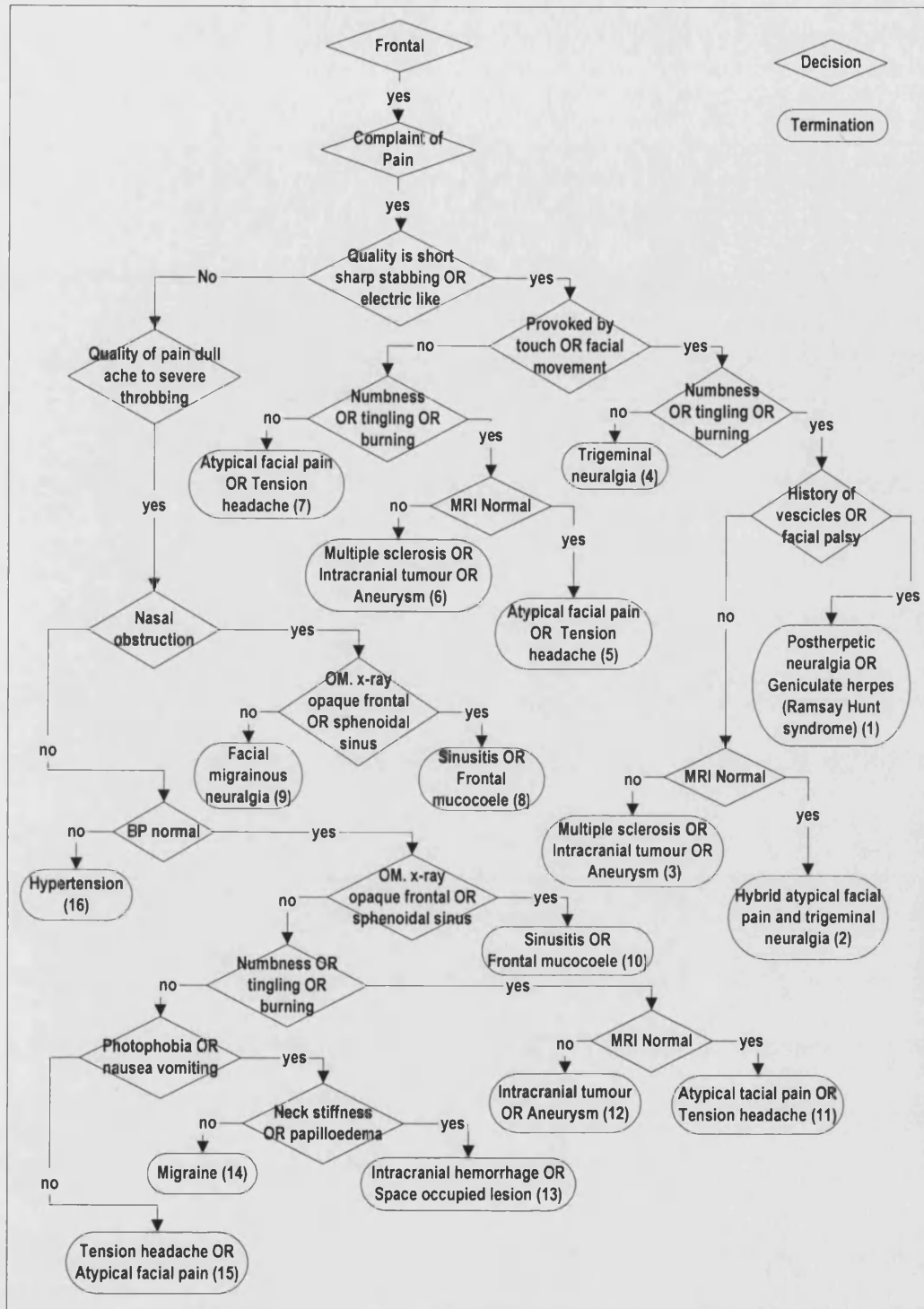


Figure 5-5: The hand-crafted decision tree for the differential diagnosis of pain in frontal region. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle. The number in the diagnosis indicates the derived rule.

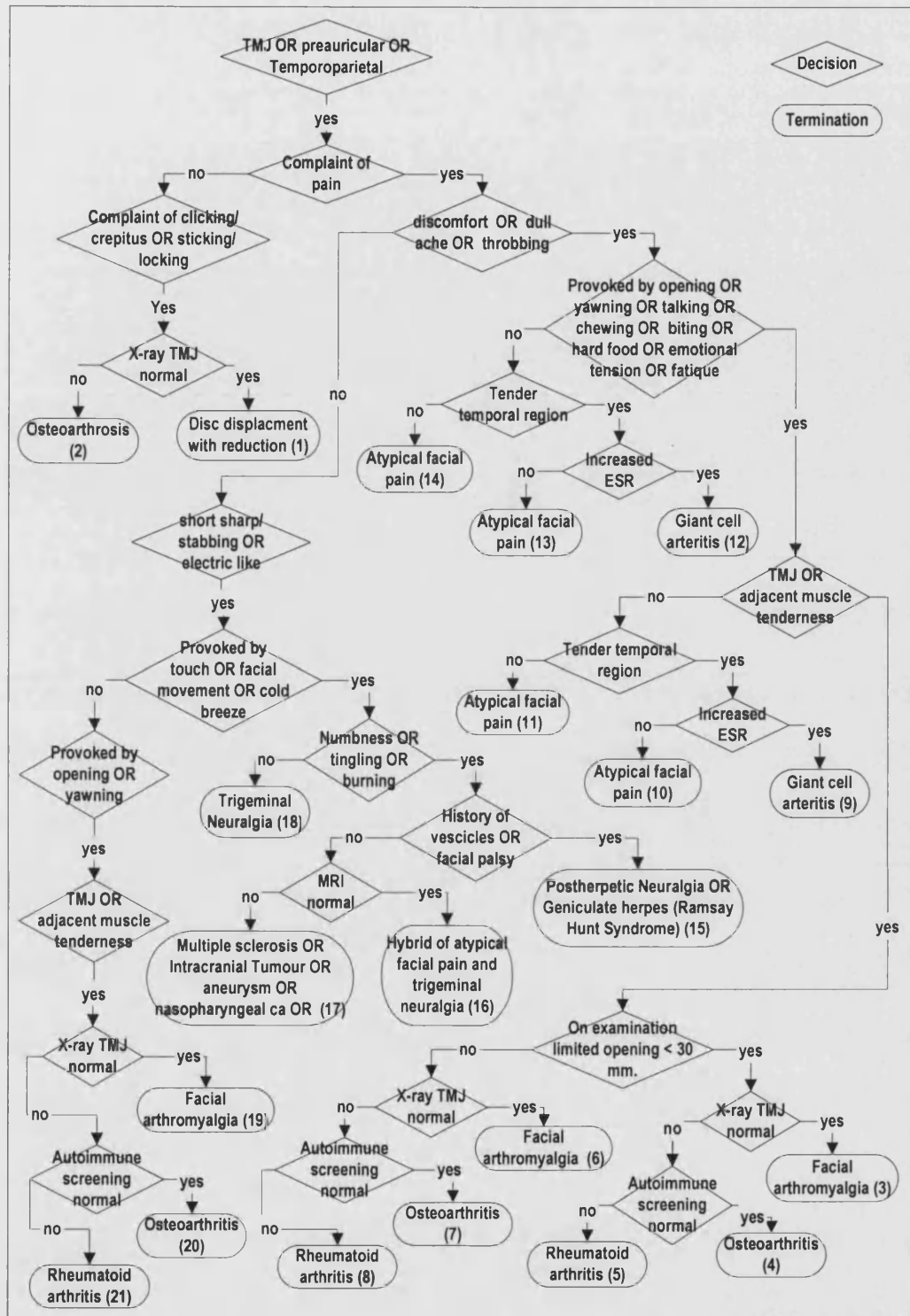


Figure 5-6: The hand-crafted decision tree for differential diagnosis of pain in TMJ and parietotemporal region. The decision node is enclosed by the diamond, whereas the diagnosis is the rounded rectangle. The number in the diagnosis indicates the derived rule.

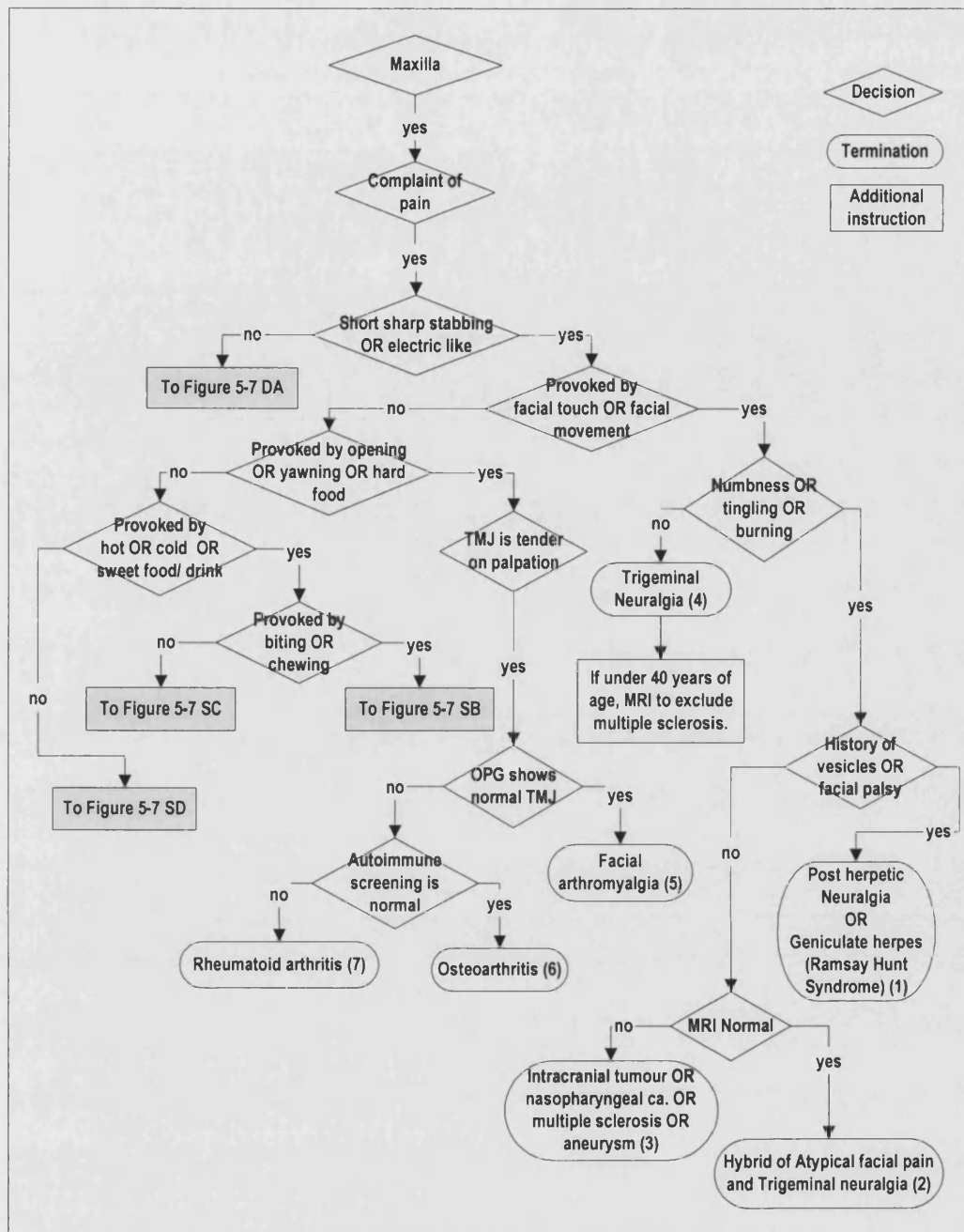


Figure 5-7 SA: Section 1 of the hand-crafted decision tree for differential diagnosis of pain in maxilla. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

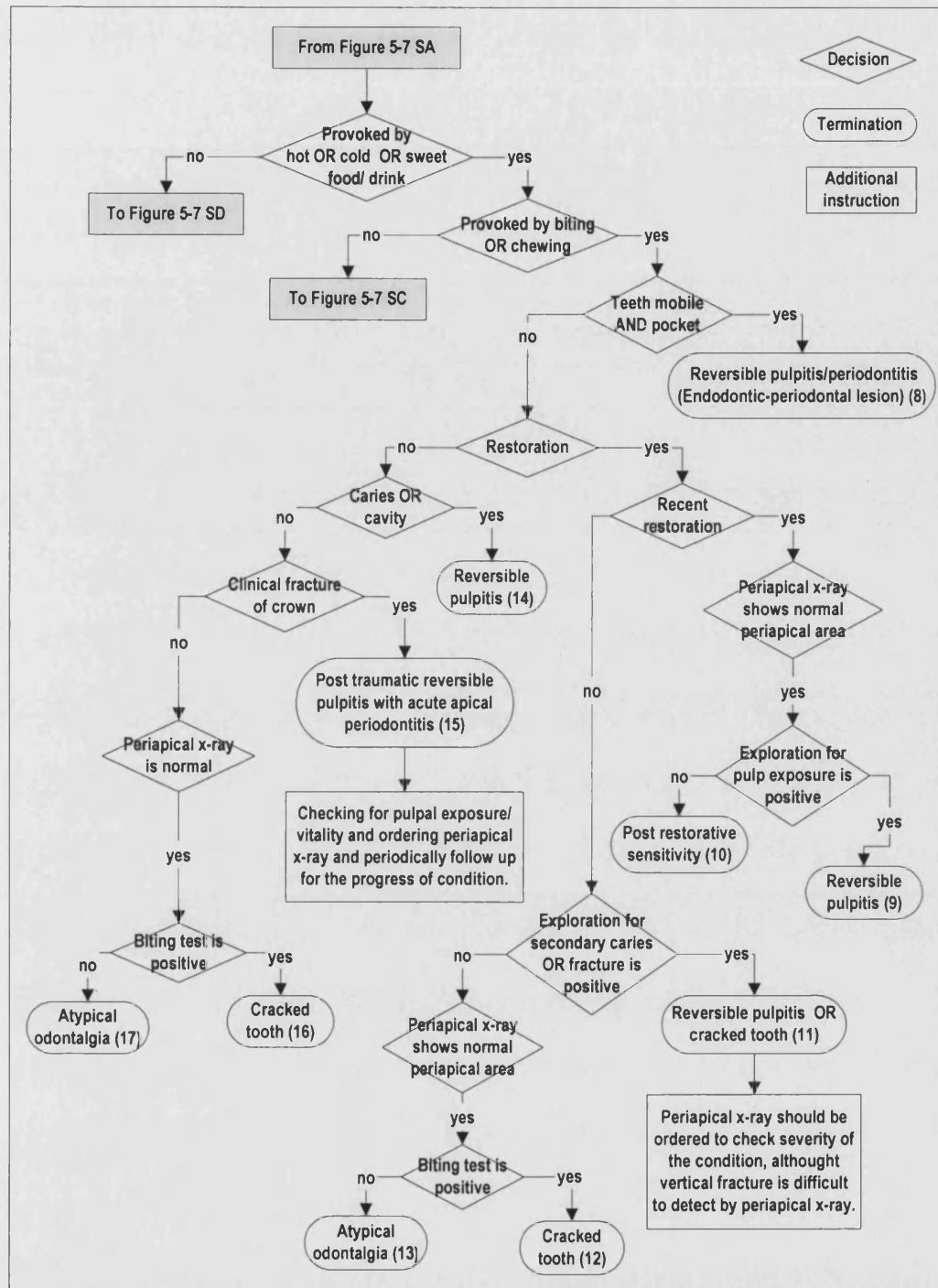


Figure 5-7 SB: Section 2 of the hand-crafted decision tree for differential diagnosis of pain in maxilla. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

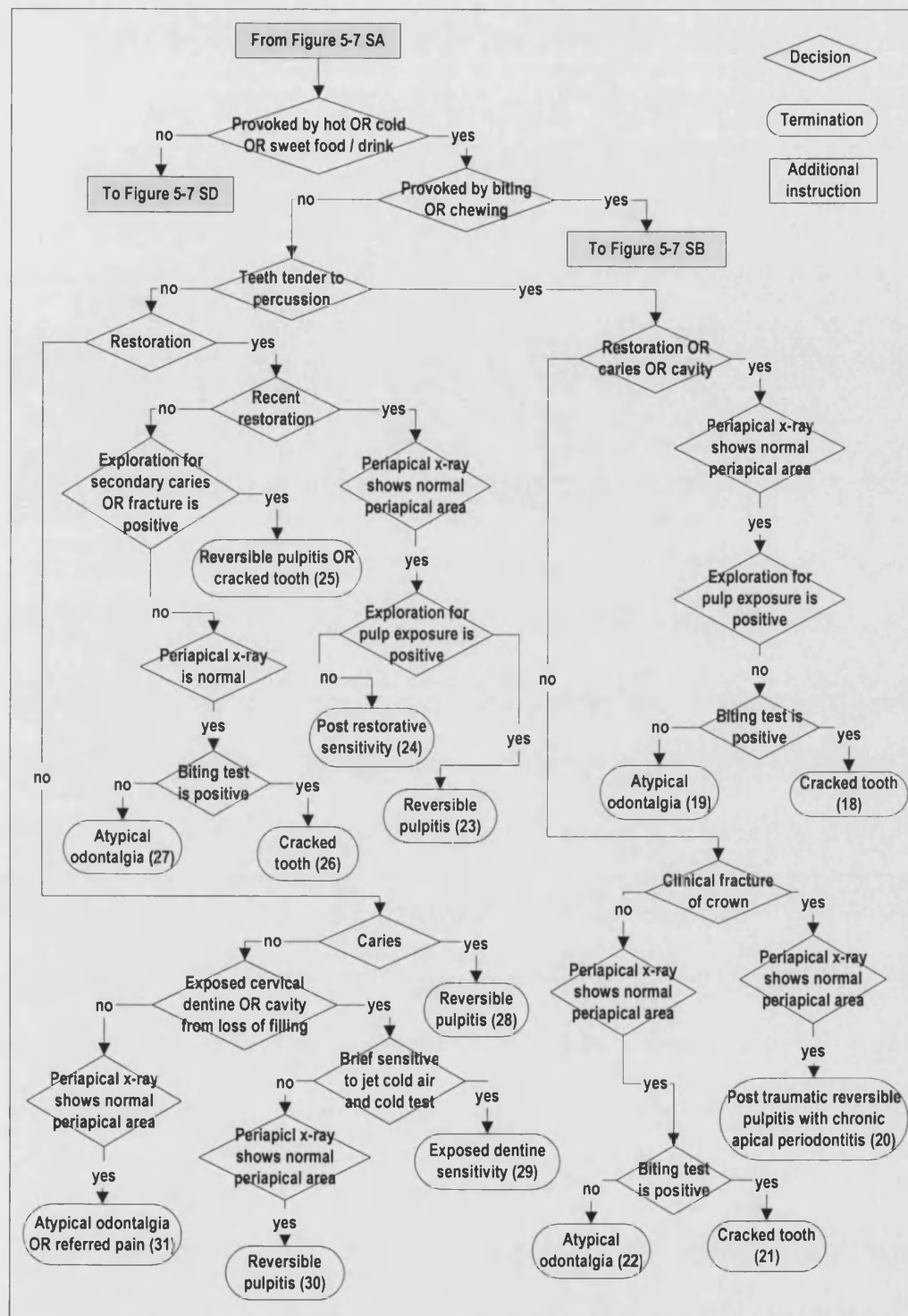


Figure 5-7 SC: Section 3 of the hand-crafted decision tree for differential diagnosis of pain in maxilla. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

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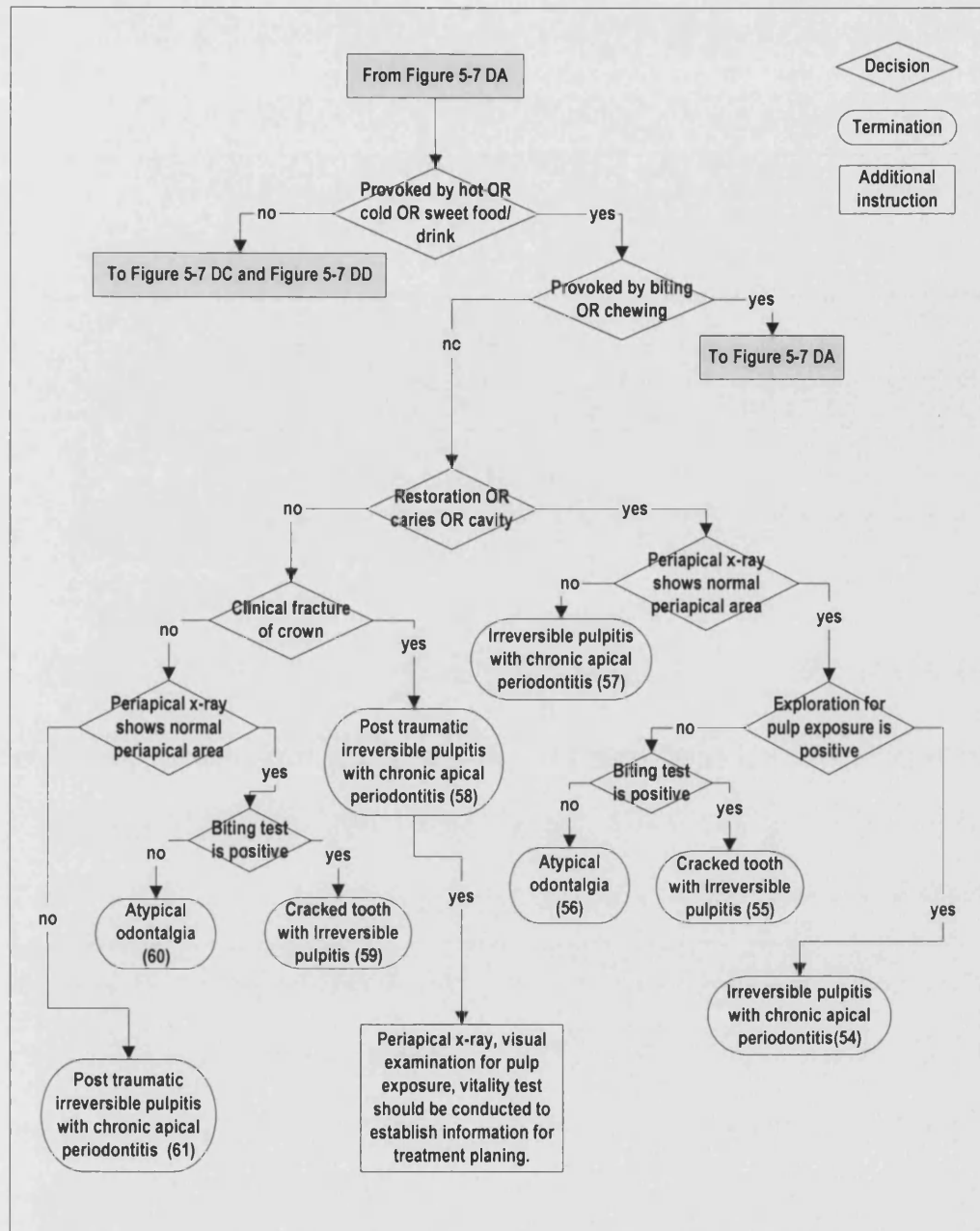


Figure 5-7 DB: Section 6 of the hand-crafted decision tree for differential diagnosis of pain in maxilla. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.



Figure 5-7 DC: Section 7 of the hand-crafted decision tree for differential diagnosis of pain in maxilla. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

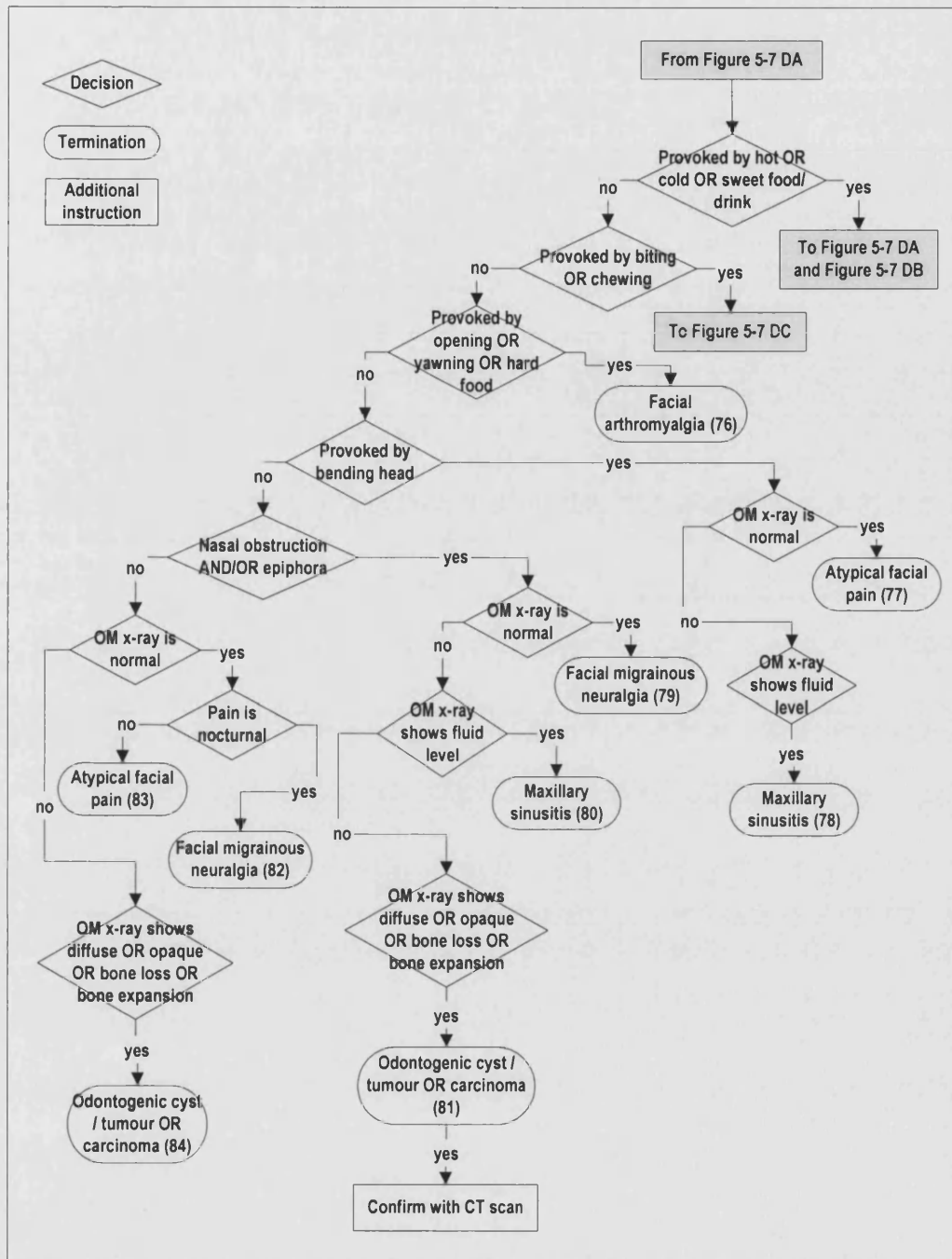


Figure 5-7 DD: Section 8 of the hand-crafted decision tree for differential diagnosis of pain in maxilla. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

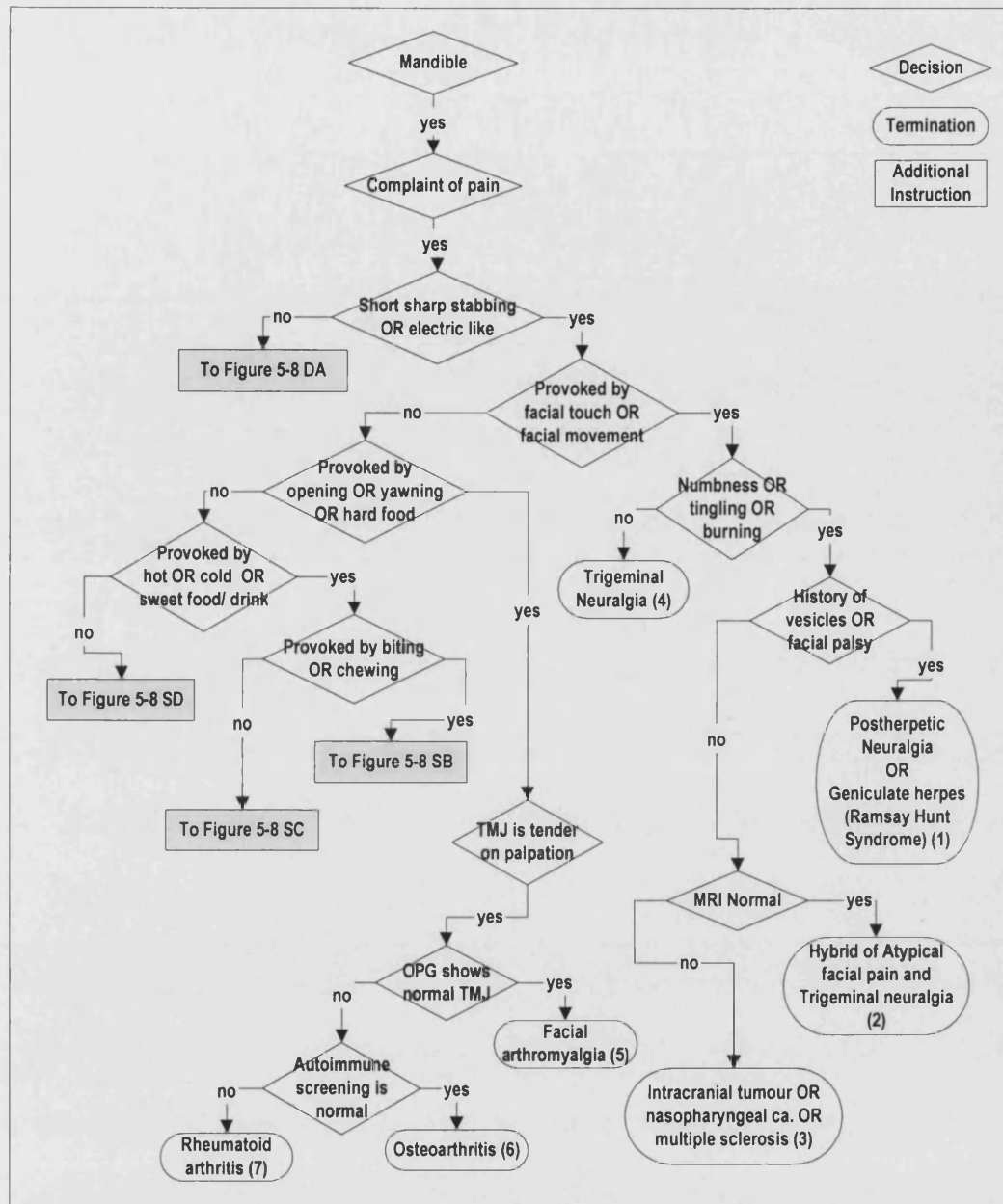


Figure 5-8 SA: Section 1 of the hand-crafted decision tree for differential diagnosis of pain in mandible. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

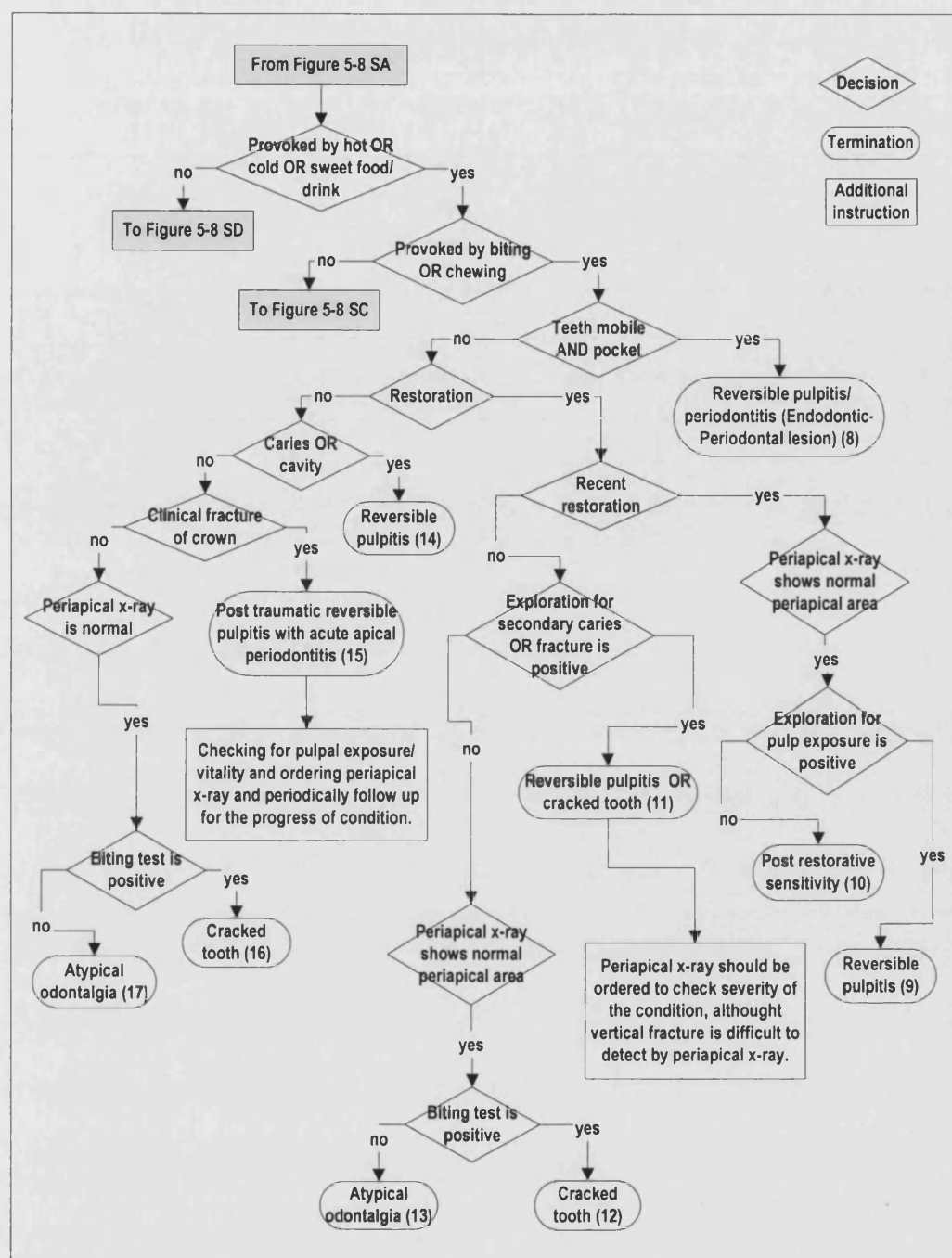


Figure 5-8 SB: Section 2 of the hand-crafted decision tree for differential diagnosis of pain in mandible. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

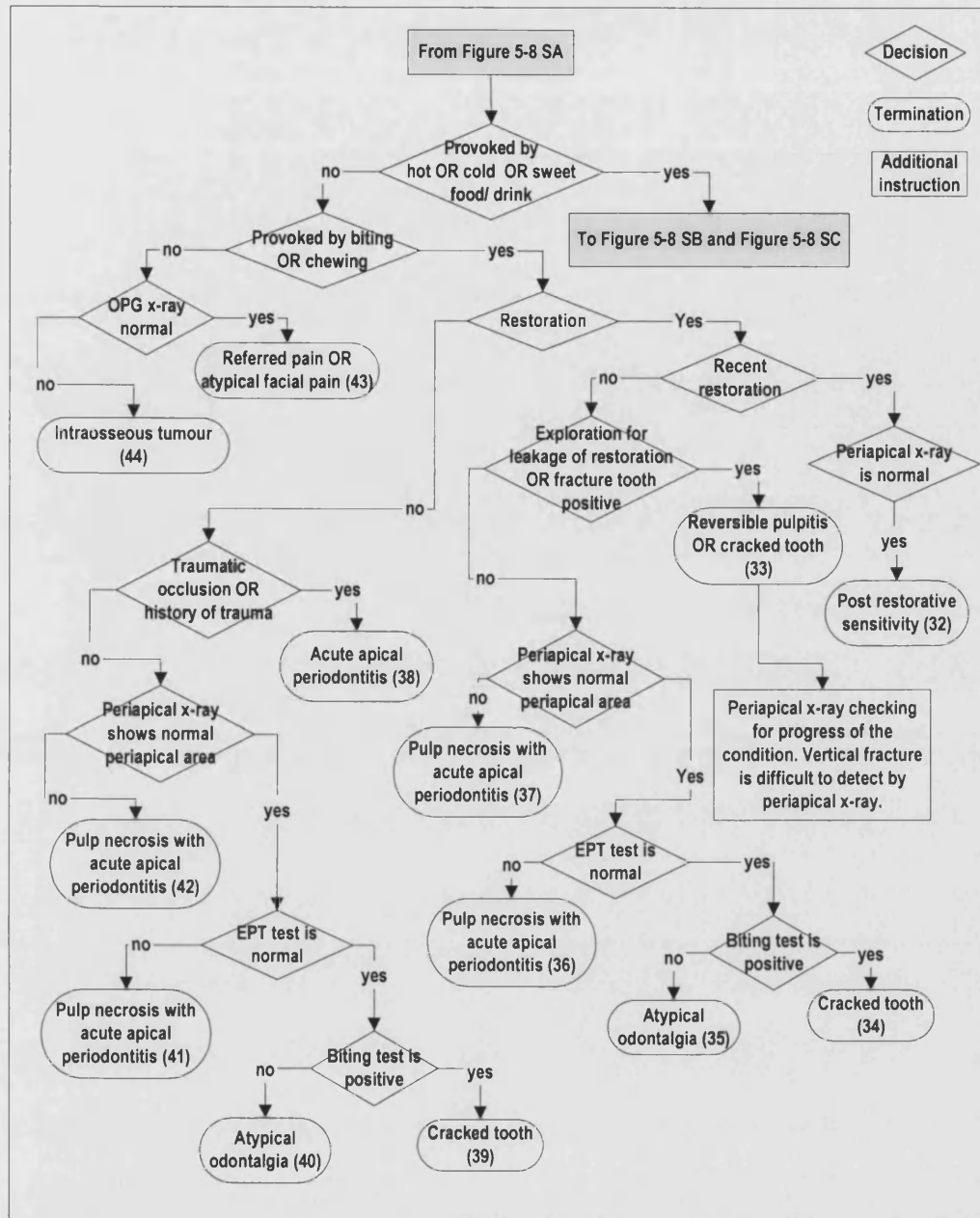


Figure 5-8 SD: Section 4 of the hand-crafted decision tree for differential diagnosis of pain in mandible. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

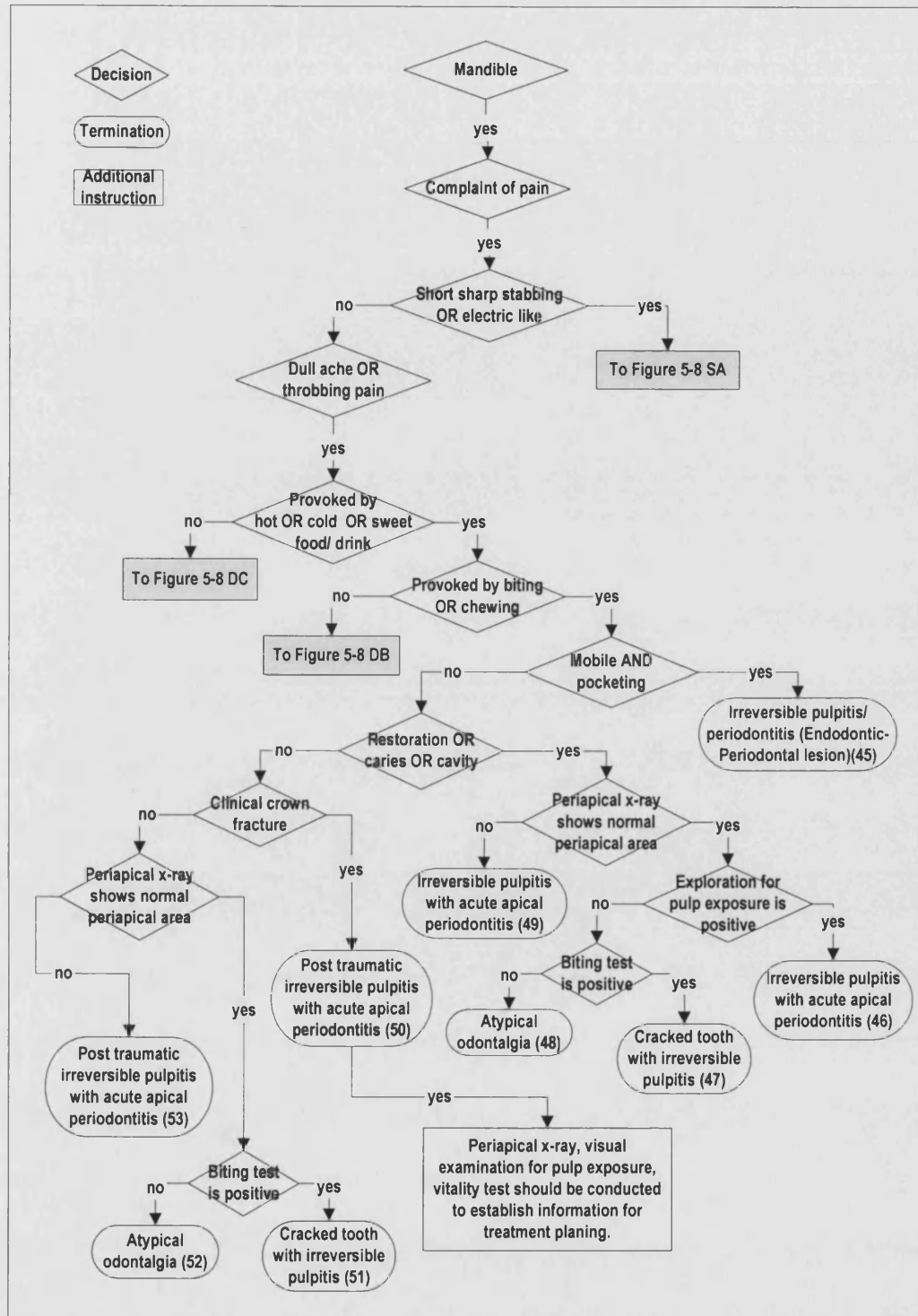


Figure 5-8 DA: Section 5 of the hand-crafted decision tree for differential diagnosis of pain in mandible. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

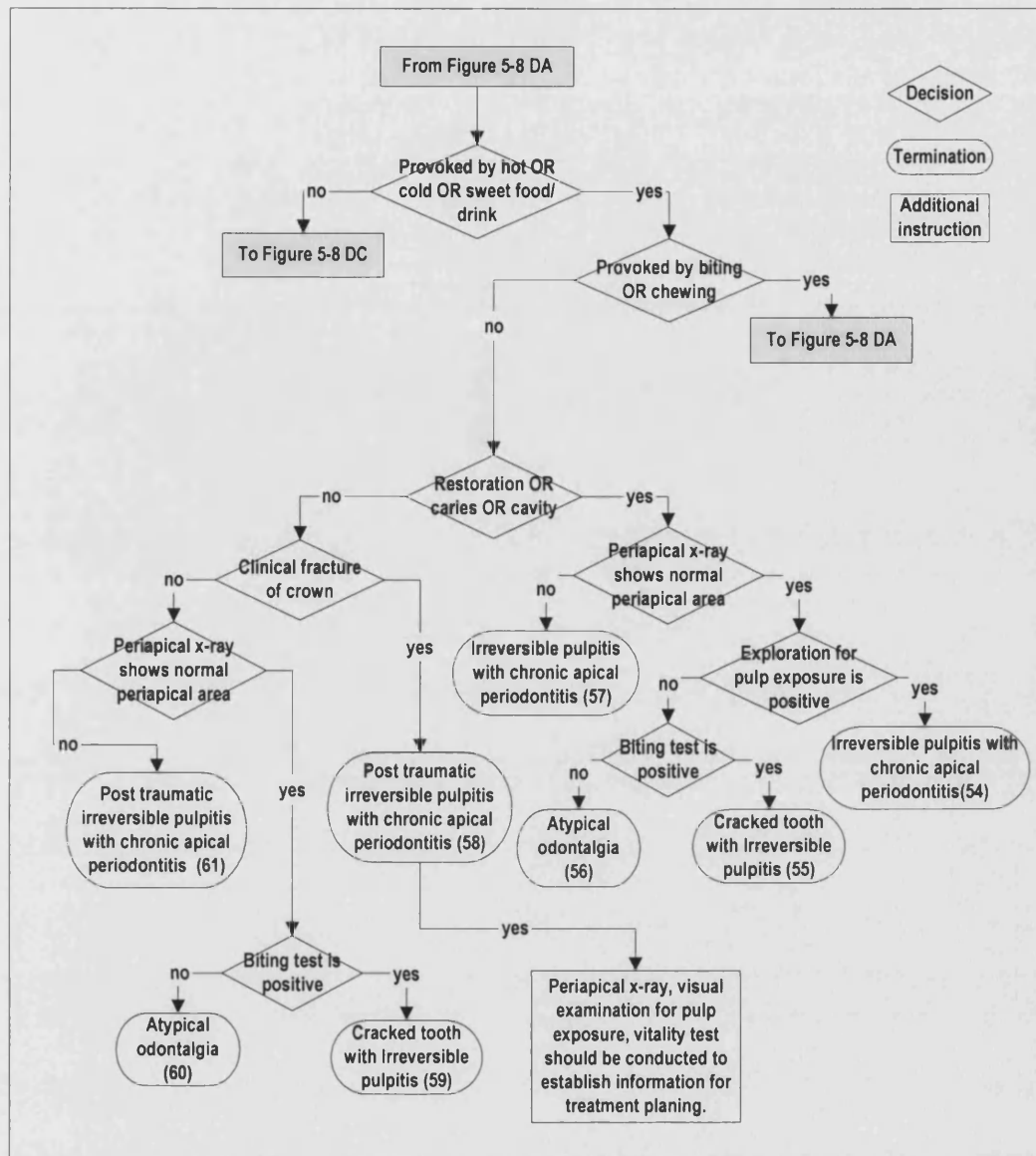


Figure 5-8 DB: Section 6 of the hand-crafted decision tree for differential diagnosis of pain in mandible. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

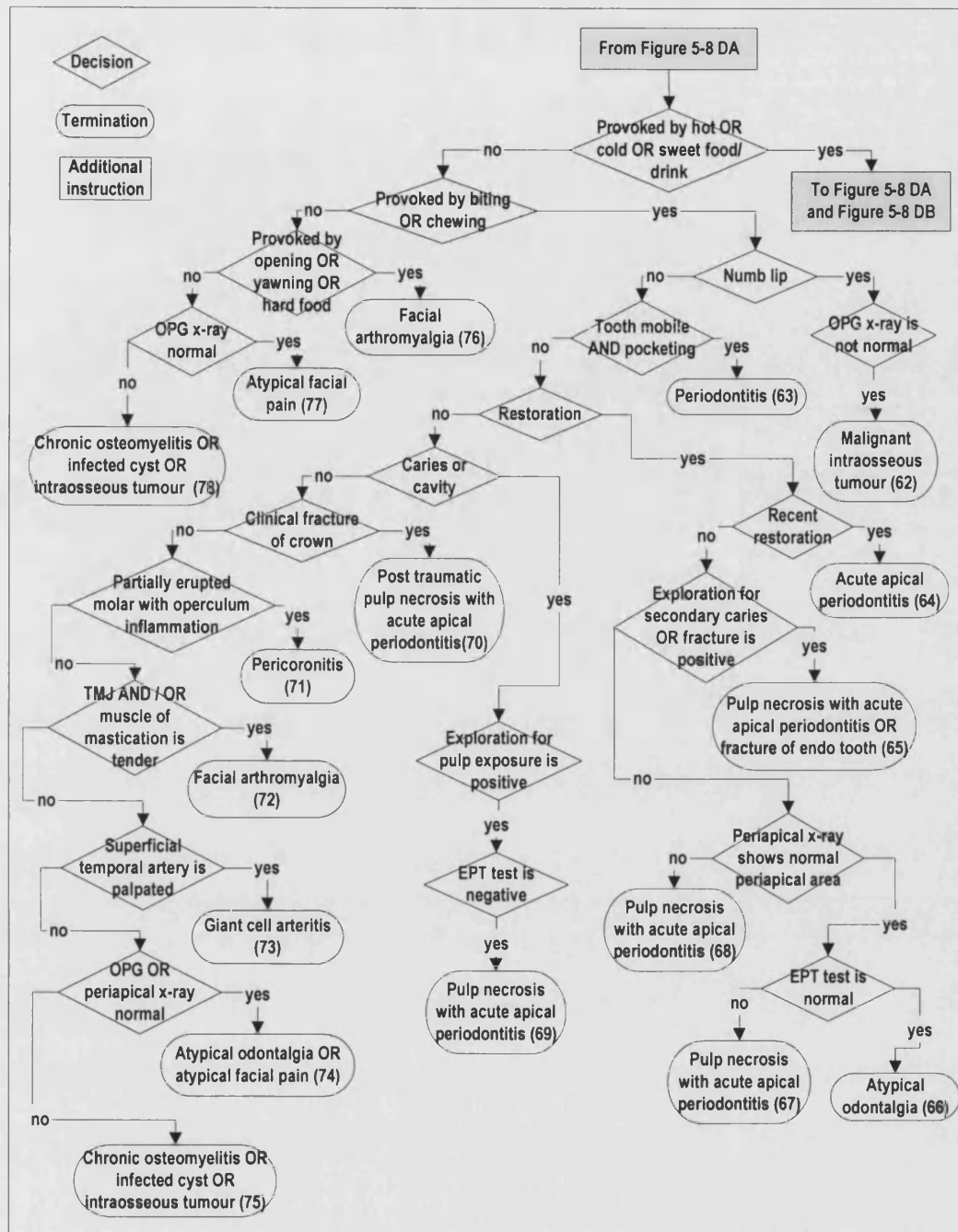


Figure 5-8 DC: Section 7 of the hand-crafted decision tree for differential diagnosis of pain in mandible. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

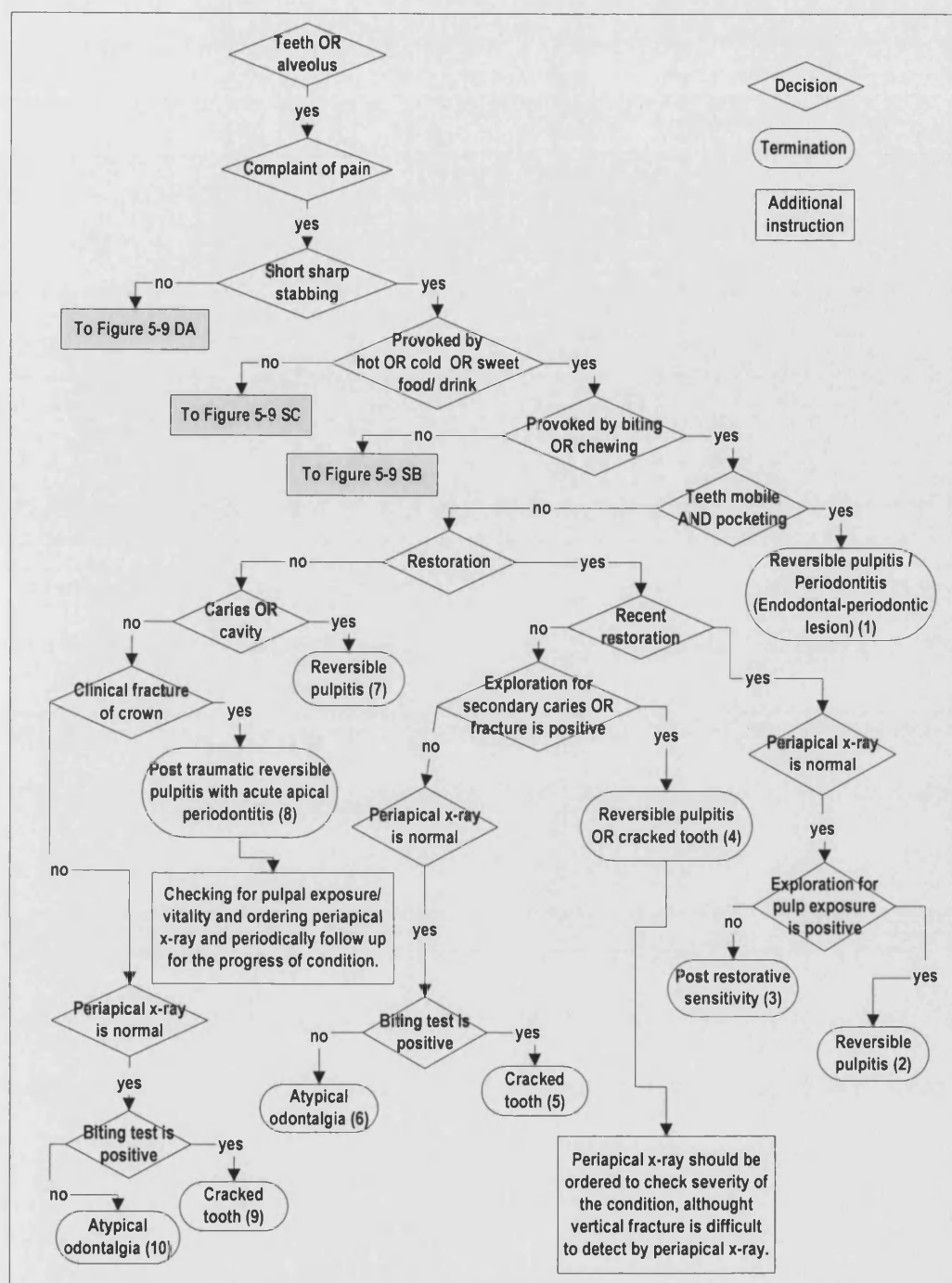


Figure 5-9 SA: Section 1 of the hand-crafted decision tree for differential diagnosis of pain in teeth and alveolus. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

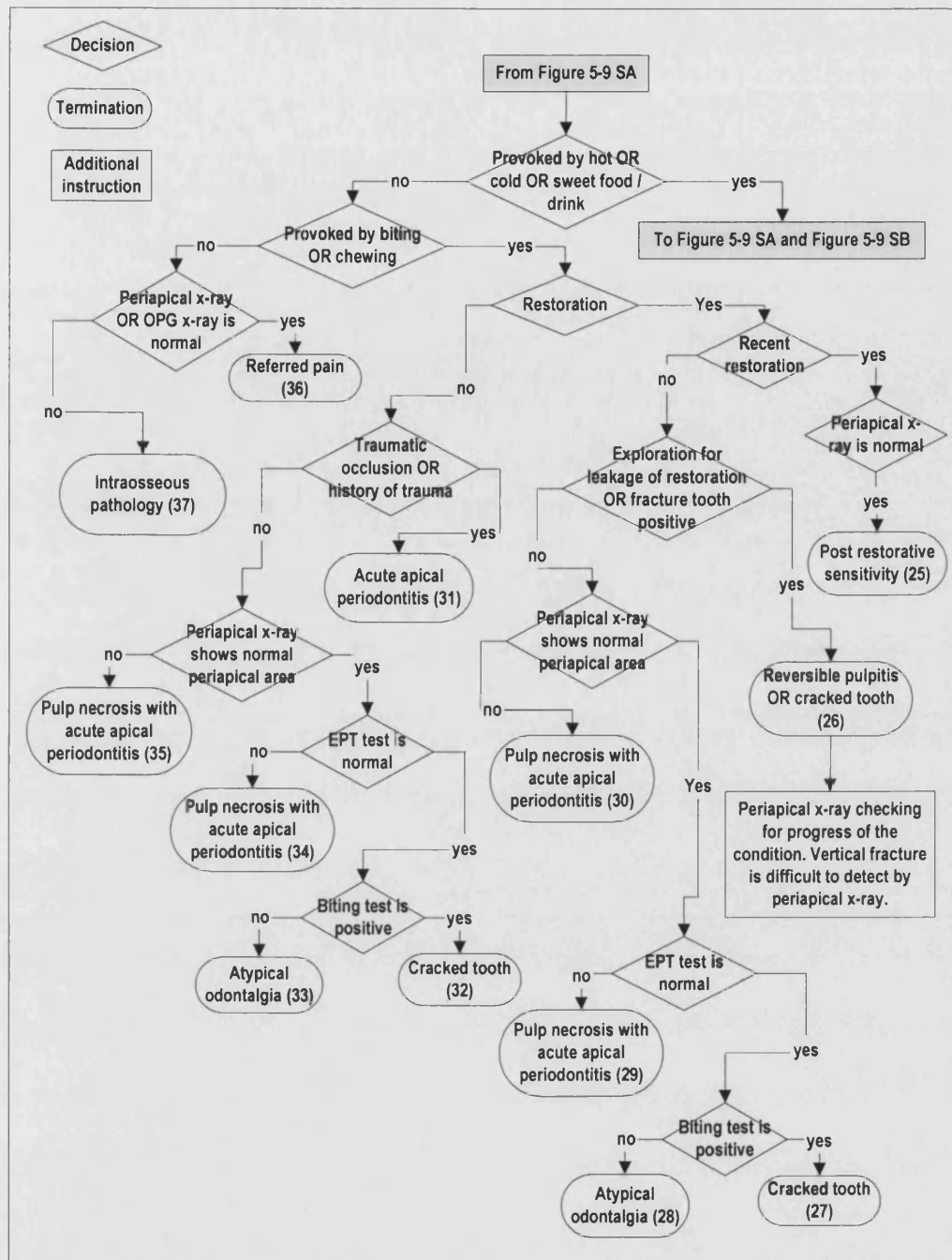


Figure 5-9 SC: Section 3 of the hand-crafted decision tree for differential diagnosis of pain in teeth and alveolus. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

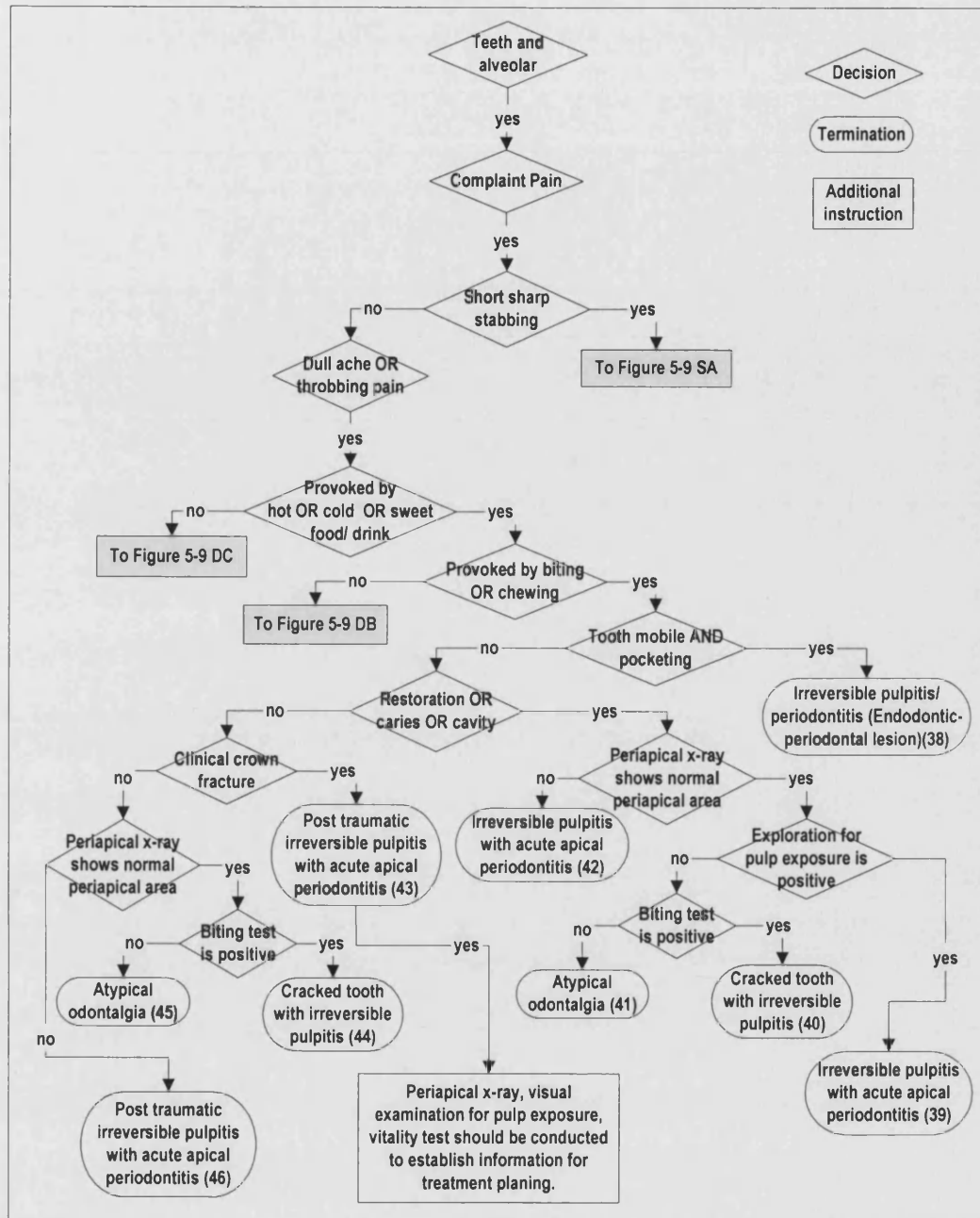


Figure 5-9 DA: Section 4 of the hand-crafted decision tree for differential diagnosis of pain in teeth and alveolus. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

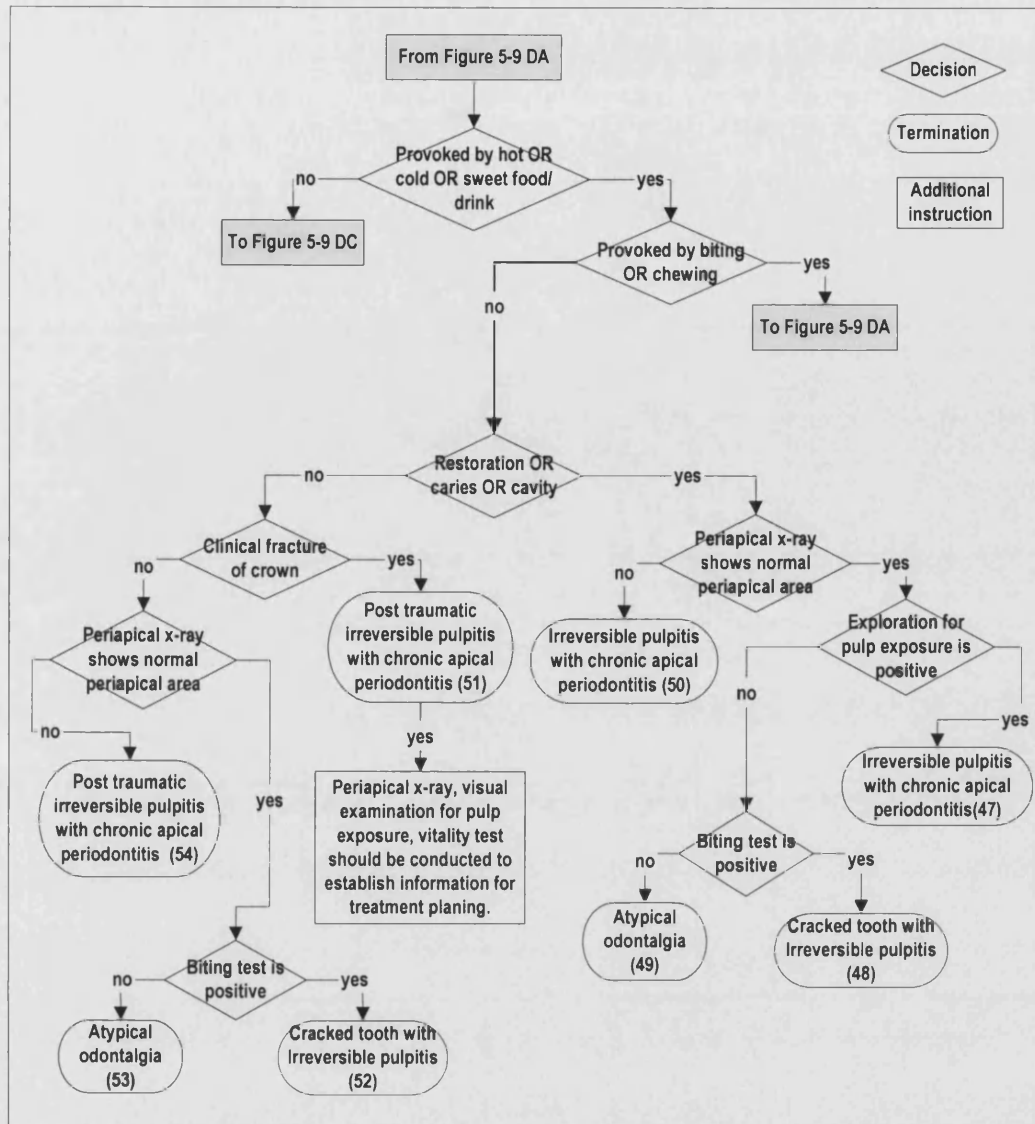


Figure 5-9 DB: Section 5 of the hand-crafted decision tree for differential diagnosis of pain in teeth and alveolus. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle.

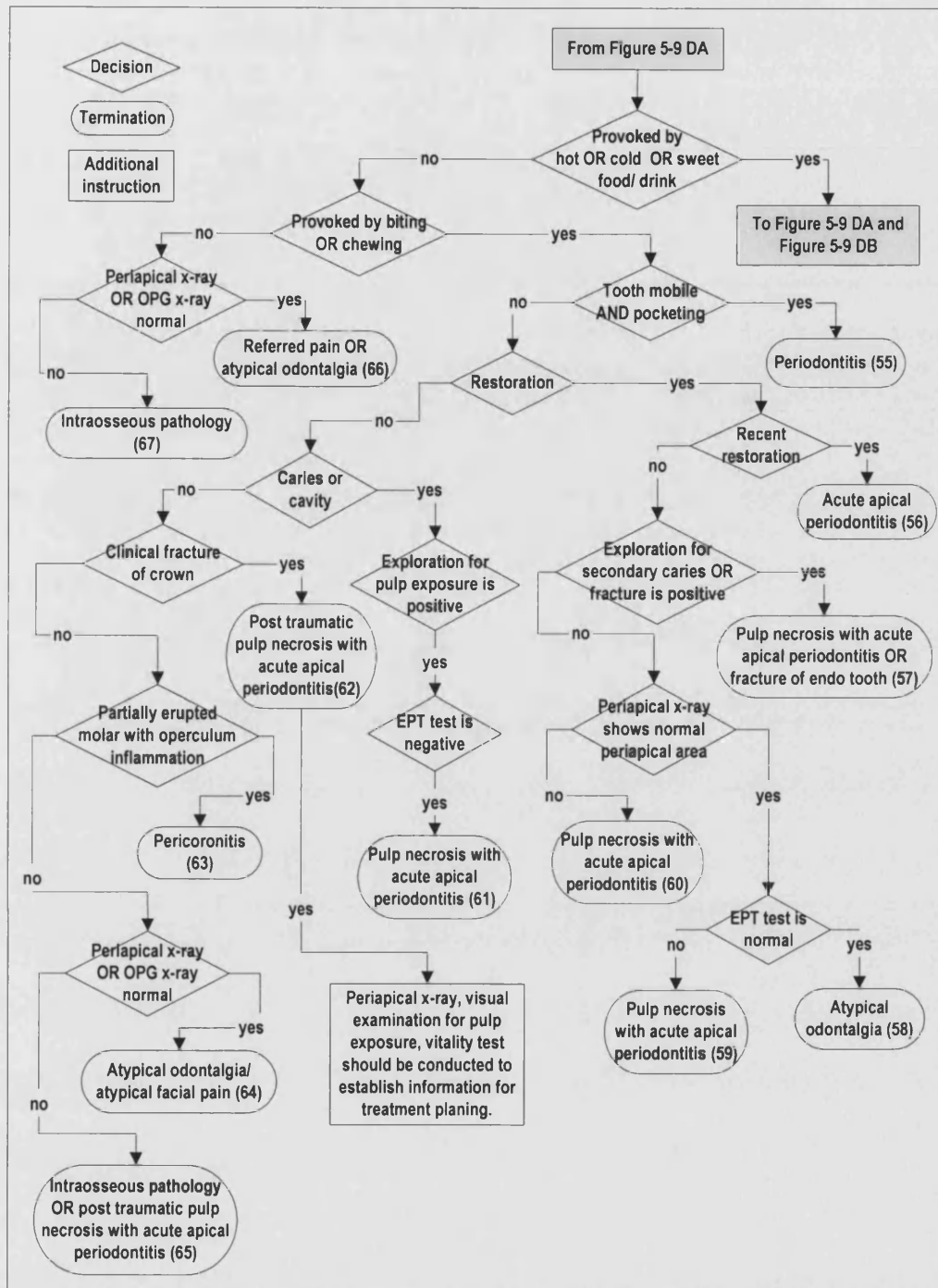


Figure 5-9 DC: Section 6 of the hand-crafted decision tree for differential diagnosis of pain in teeth and alveolus. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

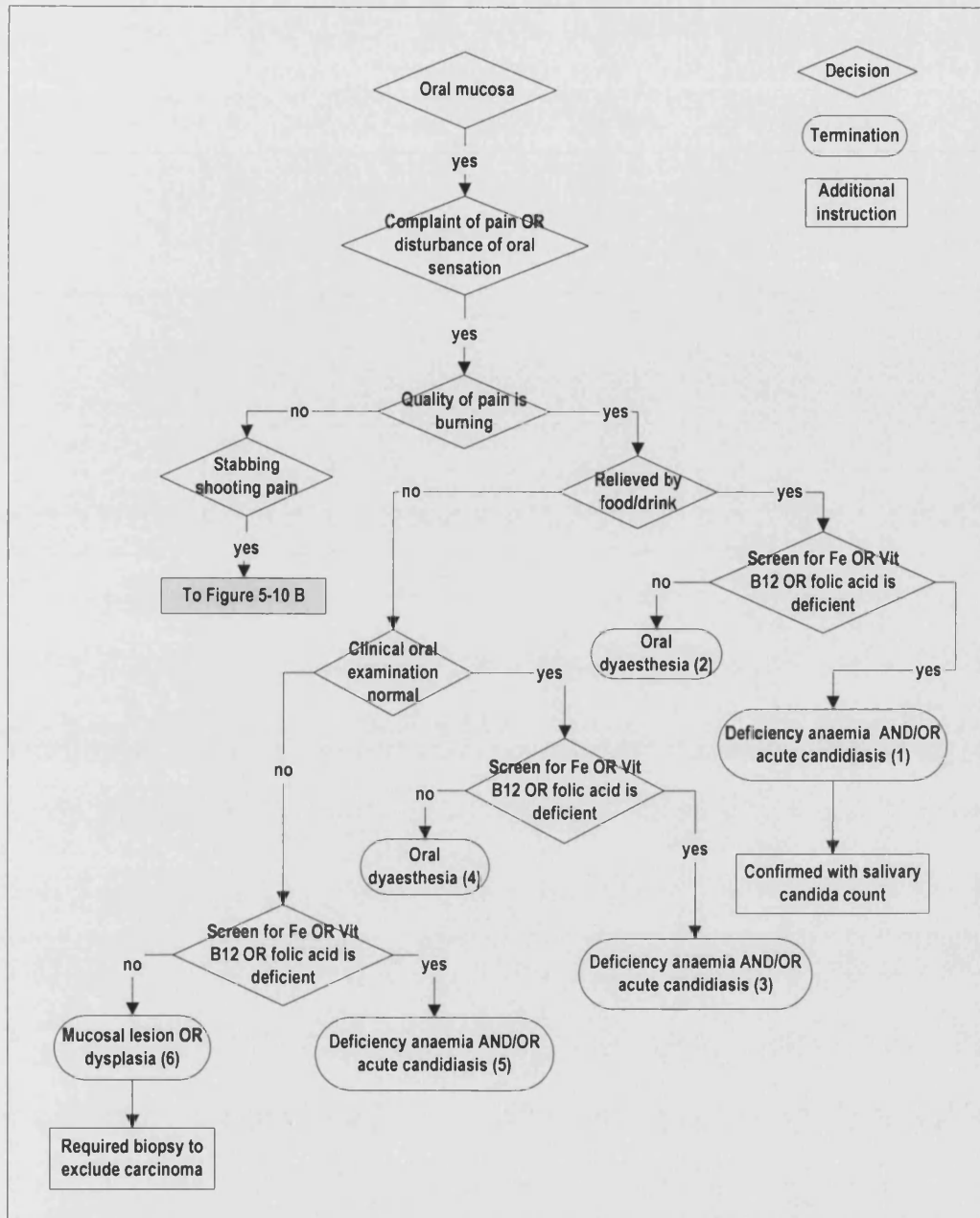


Figure 5-10 A: Section 1 of the hand-crafted decision tree for differential diagnosis of pain in oral mucosa. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the addition instruction is the rectangle. The number in the diagnosis indicates the derived rule.

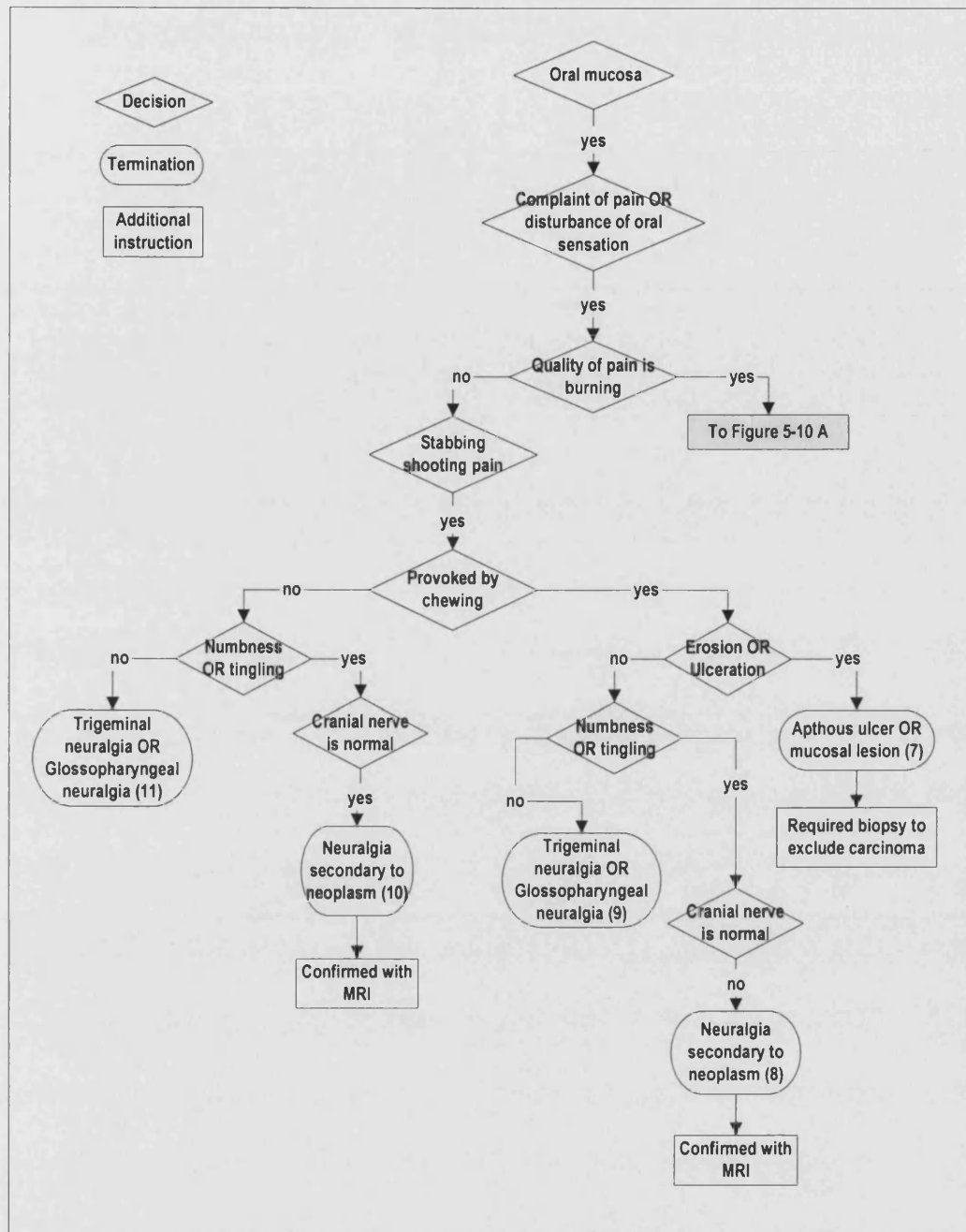


Figure 5-10 B: Section 2 of the hand-crafted decision tree for differential diagnosis of pain in oral mucosa. The decision node is enclosed by the diamond, where as the diagnosis is the rounded rectangle and the additional instruction is the rectangle. The number in the diagnosis indicates the derived rule.

5.9. Discussion

The differential diagnosis of CFP is discussed separately for each area of pain followed by indicating the constraints arising from modelling this knowledge.

5.9.1. Hand-crafted Decision Tree of the Frontal Region

The knowledge for the differential diagnosis of pain in frontal region is illustrated in Figure 5-5. There are 16 diagnostic rules which could be considered as “routes” or “pathways” derived in this decision tree and they are documented in Appendix B.1. Therefore the possible conditions which present with pain in the frontal region are summarised in Table 5-3.

Table 5-3: Possible conditions presenting with pain in frontal region subclassified as sharp or dull/throbbing.

Group	Sharp quality	Dull/throbbing quality
CIFP	<ul style="list-style-type: none"> atypical facial pain 	<ul style="list-style-type: none"> atypical facial pain
Neuropathy (primary and secondary)	<ul style="list-style-type: none"> trigeminal neuralgia post herpetic neuralgia or geniculate herpes (in combination with burning pain) multiple sclerosis intracranial tumour e.g. acoustic neuroma, meningioma aneurysm of internal carotid artery 	Nil
Headache syndromes	<ul style="list-style-type: none"> tension headache 	<ul style="list-style-type: none"> facial migrainous neuralgia tension headache migraine with or without aura intracranial hemorrhage intracranial tumour e.g. acoustic neuroma, meningioma aneurysm of internal carotid artery
Frontal/ethmoidal sinuses	Nil	<ul style="list-style-type: none"> frontal/ethmoidal sinusitis mucocoele
Cardiovascular disease	Nil	<ul style="list-style-type: none"> hypertension
hybrid	<ul style="list-style-type: none"> hybrid of atypical facial pain 	<ul style="list-style-type: none"> hybrid of atypical facial pain

Group	Sharp quality	Dull/throbbing quality
	and trigeminal neuralgia	and trigeminal neuralgia

Another condition which can occur in the frontal region is paroxysmal hemicrania which was first described by Sjaastad and Dale (1974) cited by Chong (2002). Paroxysmal hemicrania has two types i.e. chronic and episodic for which the relationship is unclear (Chong 2002). It is an uncommon condition for which diagnostic criteria are not clear and often overlapping with facial migrainous neuralgia. It is still debatable whether these two conditions are separate entities or two extreme of a spectrum of headache. Therefore, it is omitted from this knowledge modelling for this time being.

It is noticed that epidemiological data are not included in this decision tree. A comprehensive review by Zakrzewska (2002a) and (2002b) has revealed evidence of epidemiological data and the characteristics of trigeminal neuralgia. There is controversy in gender through out many studies suggesting females have preponderance over males. Age of onset is 50-60 year old which is not a strong predictor for differential diagnosis from other facial pain condition. Location of pain is mostly unilateral with a few percentage of patients have bilateral but this has less power to differentiate from other conditions. The quality of pain is the strongest predictor for diagnosis, about 95-70% of patients have sharp stabbing cutting or shooting pain. Provoking factors are also strong predictors for the presence of trigeminal neuralgia for which one study indicated that most of trigeminal neuralgia has provoking factor (95% confidence interval (CI) 98.5–93.5) unlike idiopathic facial pain. The provoking factors most frequently reported are light touch, chewing, talking, trigger areas. Objective numbness or tingling or burning which are signs of nerve damage and are used to diagnose intracranial tumours, hybrid of atypical facial pain and trigeminal neuralgia (AFP/TN), post herpetic neuralgia, multiple sclerosis (MS), and aneurysm. A history of previous vesicles and facial palsy are reserved for the further differential diagnosis of post herpetic neuralgia and geniculate herpes (Ramsay Hunt Syndrome) respectively, whereas magnetic resonance imaging (MRI) is reserved for the differential diagnosis of the hybrid AFP/TN from MS, intracranial tumour of the posterior fossa (e.g. meningioma, acoustic neuroma), and aneurysm.

One may argue that other symptoms which have a strong predictive value may include age since older patients tend to have trigeminal neuralgia, but this spectrum of age can overlap with the wide spectrum of age in other orofacial pains such as atypical facial pain. However intracranial lesions such as tumours and multiple sclerosis occur in young patients (less than 50 years of age) with a combination of symptoms and signs of numbness/tingling/burning.

A study of Boureau et al. (1990), cited from a comprehensive review of Dworkin (2002), revealed that most neuropathic patients describe more than one type of pain, that is, their pain has several different qualities. Electric shock, burning and tingling were the adjectives which were chosen by patients with neuropathic pain.

Dull ache or severe throbbing is used to classify sinusitis, frontal mucocoele, facial migrainous neuralgia, atypical facial pain, tension headache, intracranial tumour, intracranial haemorrhage, migraine, and hypertension. The majority of patients with facial migrainous neuralgia have autonomic associated features (Chong 2002). Nasal obstruction which may be caused by oedema of the nasal mucous membrane from autonomic nervous function is used to differentiate diagnosis of facial migrainous neuralgia from frontal sinusitis, and frontal mucocoele. Other autonomic associated symptoms such as lacrimation, conjunctival injection, ptosis/eyelid swelling, and rhinorrhea are also reported symptoms in facial migrainous neuralgia. These “secondary” symptoms have not been included because the decision tree will be too big with such branches. Occipitontal radiography (OM x-ray) plays a crucial role in the differential diagnosis of sinusitis and mucocoele from facial migrainous neuralgia. Radiographic investigation (OM x-ray) is used again for differential diagnosis of sinusitis and mucocoele from group of possible conditions such as atypical facial pain, tension headache, migraine, intracranial haemorrhage, intracranial tumour, and aneurysm. Neurological sensory signs and more important the MRI are used to differential diagnosis intracranial tumour whereas photophobia/nausea vomiting are used for differential diagnosis of tension headache and atypical facial pain, neck stiffness or pupilloedema are used for differential diagnosis of migraine and intracranial haemorrhage. High blood pressure is used to exclude hypertensive pain.

Although nasal obstruction is a reliable predictor of sinusitis (Kenny et al. 2001) (Rosbe & Jones 1998) and CT scanning is now considered the most sensitive and specific diagnostic method, occipitomental radiography can still be used for the differential diagnosis of sinusitis of the frontal and sphenoidal sinus. With numbness and tingling or burning associated symptoms on the dull ache pathway, the MRI is used to exclude atypical facial pain and tension headache from structural pathology. The distinction between AFP and the tension headache in the frontal area is often unclear and may be of little significance therapeutically when the “tension headache” does not respond to simple analgesics.

5.9.2. Hand-crafted Decision Tree of the TMJ Region

The data used for the diagnosis of pain, or clicking or sticking/locking in TMJ region and parietotemporal region (including preauricular, postauricular, temple, and parietal) is illustrated in the hand-crafted decision tree Figure 5-6. Twenty one rules (diagnostic pathways) from the hand-crafted decision tree are documented in Appendix B.2. The possible conditions presenting with pain in TMJ and parietotemporal region are summarised in Table 5-4.

Table 5-4: Possible conditions presenting with pain in TMJ and parietotemporal region subclassified as sharp or dull/throbbing.

Group	Sharp quality	Dull/throbbing quality
CIFP	<ul style="list-style-type: none"> facial arthromyalgia 	<ul style="list-style-type: none"> facial arthromyalgia atypical facial pain atypical odontalgia
Inflammatory disease	<ul style="list-style-type: none"> osteoarthritis rheumatoid arthritis 	<ul style="list-style-type: none"> osteoarthritis rheumatoid arthritis
Vasculitis	Nil	<ul style="list-style-type: none"> giant cell arteritis (temporal arteritis)
Cancer	<ul style="list-style-type: none"> nasopharyngeal carcinoma 	Nil
Neuropathy (primary and secondary)	<ul style="list-style-type: none"> trigeminal neuralgia herpetic neuralgia or geniculate herpes (in combination with burning pain) 	<ul style="list-style-type: none"> intracranial tumour e.g. acoustic neuroma, meningioma aneurysm of internal carotid artery

Group	Sharp quality	Dull/throbbing quality
	<ul style="list-style-type: none"> multiple sclerosis intracranial tumour e.g. acoustic neuroma, meningioma aneurysm of internal carotid artery 	
Hybrid	<ul style="list-style-type: none"> hybrid of atypical facial pain and trigeminal neuralgia 	<ul style="list-style-type: none"> hybrid of atypical facial pain and trigeminal neuralgia

The hand-crafted decision tree starts with the location of complaints in the TMJ or temporoparietal areas (including temple, parietal, and postauricular area). Two type of complaints are used i.e. (1) pain and (2) clicking or crepitus or sticking or locking without pain. The complaint of dysfunction without pain will lead to a diagnosis of disc displacement with reduction or osteoarthritis. The signs of bony changes are osteophyte formation, erosion of the condylar head, subchondral sclerosis, and flattening of the condyle surface. The major types of pain (1) discomfort or dull ache or throbbing and (2) sharp or stabbing or electric like are used for refining the diagnosis. Provoking factors, clinical examination, radiography and autoimmune screening data (to exclude the rare rheumatoid arthritis and temporal arteritis are further used for the differential diagnosis in the pathway of the hand-crafted decision tree.

It should be noted that the term facial arthromyalgia is the same as the Temporomandibular pain and dysfunction syndrome (International Association for the Study of Pain; Merskey and Bogduk, 1994) and the definition of International Headache Society (1988). A broad definition is preferred to other specific classifications because, current evidence does not promote a more definitive subclassification of facial arthromyalgia and most patients with facial arthromyalgia seek treatment because of pain not dysfunction. However, the diagnosis of solely clicking/crepitus or sticking/locking is needed to identify disc displacement with reduction or osteoarthritis. Limited mouth opening is used in the decision tree as it is related to the severity of pain (Hesse, van Loon, & Naeije 1997).

The criteria of diagnosis of giant cell arteritis is based on pain, tender temporal artery, and raised ESR >50 and this is similar to the 1990 criteria for the

classification of the American College of Rheumatology (American College of Rheumatology 2002). The differential diagnosis of rheumatoid arthritis and osteoarthritis is based on the autoimmune profile of patients.

The diagnosis of pain from trigeminal neuralgia, post herpetic neuralgia, multiple sclerosis, intracranial tumour, aneurysm, hybrid AFP/TN, and nasopharyngeal carcinoma are possible in this area and the pathway of the decision tree is similar to the frontal hand-crafted decision tree.

5.9.3. Hand-crafted Decision Tree of the Maxilla Region

The knowledge pathways (rules) for the differential diagnosis of sharp quality pain is illustrated in Figures 5-7 SA, SB, SC, SD, whereas Figures 5-7 DA, DB, DC, DD depict the knowledge pathways for the differential diagnosis of dull quality pain. Forty four rules derived from 4 hand-crafted decision trees of sharp quality whereas 40 rules were from 4 hand-crafted decision trees of dull quality, and they are documented in Appendix B.3. The possible conditions presenting both qualities of pain in the maxillary region are summarised in Table 5-5.

Table 5-5: Possible conditions presenting with pain in maxilla region subclassified as sharp or dull/throbbing.

Group	Sharp quality	Dull/throbbing quality
Dental	<ul style="list-style-type: none"> • reversible pulpitis • endodontic-periodontal lesion • post restorative dentinal sensitivity • cracked tooth • post traumatic reversible pulpitis with acute apical periodontitis • exposed dentine sensitivity • pulp necrosis with acute apical periodontitis • acute apical periodontitis 	<ul style="list-style-type: none"> • irreversible pulpitis • endodontic-periodontal lesion • irreversible pulpitis with acute apical periodontitis • irreversible pulpitis with chronic apical periodontitis • cracked tooth with irreversible pulpitis • post traumatic irreversible pulpitis with acute apical periodontitis • post traumatic irreversible pulpitis with chronic apical periodontitis • acute apical periodontitis • periodontitis

Group	Sharp quality	Dull/throbbing quality
		<ul style="list-style-type: none"> pulp necrosis with acute apical periodontitis post traumatic pulp necrosis with acute apical periodontitis pericoronitis
CIFP	<ul style="list-style-type: none"> facial arthromyalgia atypical facial pain (uncommon) atypical odontalgia (uncommon) 	<ul style="list-style-type: none"> facial arthromyalgia atypical facial pain atypical odontalgia
Maxillary sinus	Nil	<ul style="list-style-type: none"> maxillary sinusitis
Cyst	Nil	<ul style="list-style-type: none"> infected odontogenic cyst
Neoplasm	<ul style="list-style-type: none"> malignant intraosseous tumour nasopharyngeal carcinoma 	<ul style="list-style-type: none"> nasopharyngeal carcinoma
Salivary gland	Nil	<ul style="list-style-type: none"> sialolithiasis
Vasculitis	Nil	<ul style="list-style-type: none"> giant cell arteritis (temporal arteritis)
Neuropathy (primary and secondary)	<ul style="list-style-type: none"> trigeminal neuralgia post herpetic neuralgia or geniculate herpes (in combination with burning pain) multiple sclerosis intracranial tumour e.g. acoustic neuroma, meningioma aneurysm of internal carotid artery 	Nil
Hybrid	<ul style="list-style-type: none"> hybrid of atypical facial pain and trigeminal neuralgia 	<ul style="list-style-type: none"> hybrid of atypical facial pain and trigeminal neuralgia
Referred pain	<ul style="list-style-type: none"> referred pain 	<ul style="list-style-type: none"> referred pain

The Rational of the Diagnosis of Maxillary Pain

For the hand-crafted decision trees of sharp pain (Figures 5-7 SA, SB, SC, SD), 4 distinct provoking factors; (1) hot or cold or sweet food/drink, (2) biting or chewing, (3) opening wide or yawning, (4) facial touch or facial movement, are used to refine the differential diagnoses. Similarly, the hand-crafted decision trees of dull/throbbing pain (Figures 5-7 DA, DB, DC, DD) used the 4 provoking

factors of (1) hot/cold/sweet, (2) biting/chewing, (3) opening/yawning, and (4) bending the head. The exploitation of hot/cold/sweet provoking factor in the hand-crafted decision tree is aimed to distinguish pulpal pain, whereas biting/chewing is used to distinguish the periodontitis/apical inflammation, cracked tooth, and post restorative sensitivity. Facial touch/facial movement provoking factor is aimed to distinguish neuropathic pain both primary and secondary, whereas opening wide/yawning provoking factor is aimed to differentiate pain from the TMJ and masticatory muscles. TMJ tenderness on palpation is used to specify whether pain has radiated from inflammation confined within the TMJ such as acute of facial arthromyalgia (Harrison 2002b), osteoarthritis, and rheumatoid arthritis and also muscular pain. Bending the head is pathognomonic for acute purulent maxillary sinusitis. The associated symptoms of numbness/tingling/burning is used for differentiation of post herpetic neuralgia, pain of secondary neuropathy, and the hybrid of atypical facial pain and trigeminal neuralgia, whereas nasal obstruction is for sinusitis, antral carcinoma or facial migrainous neuralgia and nocturnal pain is exclusive to facial migrainous neuralgia. Important history data include; (1) history of recent restoration, (2) history of trauma on the tooth and face, and (3) history of vesicles on the face and intraoral mucosa, are employed for further refining. The data from various clinical examinations; (1) mobile and pocketing of teeth, (2) presence of a restoration, (3) caries/cavities, (4) fractured of teeth; (5) pulp exposure, (6) traumatic occlusion, and (7) leakage of restoration, are combined with previous clinical data to make a diagnosis. In some circumstance, this process needs additional data from diagnostic tests such as EPT test, percussion test, and biting test, as well as the results of radiography to make a diagnosis.

Pain of dental origin can arise from pulpal inflammation, periapical inflammation, and periodontitis. Pain from the malignant transformation of odontogenic lesions is very rare. Patients with a benign odontogenic neoplasm usually do not present with a complaint of pain provided that there is no secondary infection. Therefore, pain from pulpal and periodontal inflammation is a major group to be distinguished from chronic idiopathic facial pain. It should be noted that the classification of pulpal disease and periodontal disease have been changed since they were firstly established. In this study, pulpal disease is now based on

clinical treatment prognosis into reversible pulpitis, irreversible pulpitis, and pulp necrosis. Periodontal pain is divided into acute apical periodontitis, chronic apical periodontitis, periodontitis and periodontal-endodontic lesion. Hence, the diagnosis of a tooth pain comprises pulpal disease status and periodontal disease status. Dentine sensitivity is a different entity of dental pain because pain results from the hydrodynamic mechanism of fluid movement rather than inflammatory substances induced pain. Post restorative sensitivity and exposed dentine sensitivity are of the entity of dentine hypersensitivity. Cracked tooth is defined as incomplete fracture of a tooth with reversible pulpitis. Pulpal status of a cracked tooth can progress to irreversible with or without apical inflammation if a tooth is left untreated.

The Validity of Pulp Testing

Although clinical symptoms of pulpal and periapical pain are well documented, the study on the validity of clinical symptoms for the diagnosis of pulpal and periapical diseases is not found in the literature. Few studies on the accuracy of thermal test, electric pulp test, and percussion test are documented (Hyman & Cohen 1984), (Peters, Baumgartner, & Lorton 1994), (Petersson et al. 1999). There are new diagnostic devices for pulpal vitality testing such as laser doppler flowmetry and pulse oximetry but these devices are still not used in a clinical setting except for research purposes. Hyman and Cohen (1984) analysed the validity of diagnostic tests (percussion test, cold test, electric pulp test, palpation test) from 5 previous published studies in which histological examining of dental pulp was a gold standard for the diagnosis of pulpal status. Although percussion is a sensitive means of detecting dental pathology, the results indicate that it has low sensitivity in detecting irreversible pulpitis and pulp necrosis, ranging from 0.38 to 0.66. Apical tenderness to palpation has very low sensitivity, ranging from 0.26 to 0.47 and low positive predictive value in detecting pulp necrosis, ranging from 0.31 to 0.36. Cold test has a low positive predictive value in detecting irreversible pulpitis and pulp necrosis ranging from 0.34 to 0.48 whereas electric pulp test give higher positive predictive value for pulp necrosis, ranging from 0.66 to 1.0. Tests with low sensitivity mean that the test has not enough capability to detect true disease in the patient. Tests with low positive predictive values mean that there is a substantial chance that patients who test positive may be free of disease (a false positive). Recent results of cold and

electric pulp tests from another study which was non-randomised and non-blinded showed a better result of positive predictive value for cold test and electric pulp test, from 0.89 and 0.88 respectively (Petersson, Soderstrom, Kiani-Anaraki, & Levy 1999).

Similar problems occur in other diagnoses which based on clinical symptoms as their mainstay such as trigeminal neuralgia (Zakrzewska 2002b). The current evidence suggests that well-controlled studies on the validity of clinical symptoms, clinical examination, and diagnostic tests for the diagnosis of pulpal and periapical disease are still lacking.

In an effort to diagnose pulpal and periapical disease in the current situation, data from history, combination of several diagnostic tests and visual examination are needed. Short sharp/stabbing pain provoked by hot/cold/sweet is a characteristic of reversible pulpal pain, whereas long standing of dull/throbbing pain provoked by hot/cold/sweet with occasionally sharp pain is a character of irreversible pulpal pain. Despite this, the explicit criteria of the diagnosis have not been established and validated. One author made an attempt to set a duration criterion of less than 1 minute to separate reversible (short duration) and irreversible (long duration) (Rowe & Pitt Ford 1990), but this is not a validated concept. The evidence of pulpal injury such as deep caries/cavities, cracked lines, recent restorations, secondary caries under restorations are important for decision making in order to confirm the diagnosis especially as atypical odontalgia can also present similar pain for which pain may triggered within the tooth and its peripheral tissue or perhaps within a central pathway.

The cracked tooth is a condition which can pose a problem in the differential diagnosis from atypical odontalgia since sometimes a cracked line is difficult to detect by direct inspection or radiography. In this decision tree, cracked tooth is distinguished from atypical odontalgia using visual examination and the biting diagnostic test.

Pain in the maxillary region as with the TMJ area may also arise from musculoskeletal origin such as facial arthromyalgia, osteoarthritis, and rheumatoid arthritis. The provoking factors (opening and yawning) and tender TMJ on palpation are used to distinguish the pain from this origin.

Neuropathic pain can arise in the maxilla region. The type of pain which is sharp, stabbing or electric like and provoking factor of facial touch or facial movement are used to distinguish this type of pain in the same way as in the frontal region. The sequential or simultaneous of atypical facial pain/atypical odontalgia and trigeminal neuralgia can occur. It is difficult to explain especially if trigeminal neuralgia follows the atypical facial pain/atypical odontalgia. This uncommon presentation tends to suggest a coincidence rather than causal relationship.

5.9.4. Hand-crafted Decision Tree of the Mandibular Region

The knowledge pathways (rules) for the differential diagnosis of sharp quality pain illustrates in Figures 5-8 SA, SB, SC, SD, whereas Figures 5-8 DA, DB, DC depict knowledge for the differential diagnosis of dull quality pain. Forty four rules were derived from 4 hand-crafted decision trees of sharp quality, whereas 34 rules were derived from 4 hand-crafted decision trees of dull quality, and they all are documented in Appendix B.4. The possible conditions presenting both quality of pain in the mandible region are summarised in Table 5-6.

Table 5-6: Possible conditions presenting with pain in mandible region subclassified as sharp and dull/throbbing.

Group	Sharp quality	Dull/throbbing quality
Dental	<ul style="list-style-type: none"> • reversible pulpitis • endodontic-periodontal lesion post restorative dentinal sensitivity • cracked tooth • post traumatic reversible pulpitis with acute apical periodontitis • exposed dentine sensitivity • pulp necrosis with acute apical periodontitis • acute apical periodontitis 	<ul style="list-style-type: none"> • irreversible pulpitis • endodontic-periodontal lesion • irreversible pulpitis with acute apical periodontitis • irreversible pulpitis with chronic apical periodontitis • cracked tooth with irreversible pulpitis • post traumatic irreversible pulpitis with acute apical periodontitis • post traumatic irreversible pulpitis with chronic apical periodontitis • acute apical periodontitis • periodontitis

Group	Sharp quality	Dull/throbbing quality
		<ul style="list-style-type: none"> pulp necrosis with acute apical periodontitis fracture of endodontic tooth post traumatic pulp necrosis with acute apical periodontitis pericoronitis
CIFP	<ul style="list-style-type: none"> facial arthromyalgia atypical facial pain (uncommon) atypical odontalgia 	<ul style="list-style-type: none"> facial arthromyalgia atypical facial pain atypical odontalgia
Cyst	Nil	<ul style="list-style-type: none"> infected odontogenic cyst
Neoplasm	malignant intraosseous tumour nasopharyngeal carcinoma	<ul style="list-style-type: none"> nasopharyngeal carcinoma
Infection of bone	Nil	<ul style="list-style-type: none"> chronic osteomyelitis (rare)
Vasculitis	Nil	<ul style="list-style-type: none"> giant cell arteritis
Neuropathy (primary and secondary)	<ul style="list-style-type: none"> trigeminal neuralgia post herpetic neuralgia or geniculate herpes (in combination with burning pain) multiple sclerosis intracranial tumour e.g. acoustic neuroma, meningioma aneurysm of internal carotid artery 	Nil
Hybrid	<ul style="list-style-type: none"> hybrid of atypical facial pain and trigeminal neuralgia 	Nil
Referred pain	<ul style="list-style-type: none"> referred pain 	<ul style="list-style-type: none"> referred pain

The rationale for the diagnosis of pain conditions in mandibular region is similar to dental causes of pain discussed in maxilla region.

5.9.5. Hand-crafted Decision Tree of the Teeth and Alveolar Region

The hand-crafted decision trees of sharp pain is illustrated in Figures 5-9 SA, SB, SC whereas Figures 5-9 DA, DB, DC are hand-crafted decision trees of dull or throbbing pain. Sixty seven rules translated from all 6 hand-crafted decision trees comprised of 37 rules from hand-crafted decision trees of sharp pain and 30 rules from those of dull or throbbing pain. All rules are documented in Appendix B.5. The possible conditions presenting with pain in teeth and alveolar region are summarised in Table 5-7.

Table 5-7: Possible conditions presenting with pain in teeth and alveolar region subclassified as sharp and dull/throbbing.

Group	Sharp quality	Dull/throbbing quality
Dental	<ul style="list-style-type: none"> • reversible pulpitis • endodontic-periodontal lesion • post restorative sensitivity • cracked tooth • post traumatic reversible pulpitis with acute apical periodontitis • exposed dentine sensitivity • pulp necrosis with acute apical periodontitis • acute apical periodontitis 	<ul style="list-style-type: none"> • irreversible pulpitis • endodontic-periodontal lesion • irreversible pulpitis with acute apical periodontitis • irreversible pulpitis with chronic apical periodontitis • cracked tooth with irreversible pulpitis • post traumatic irreversible pulpitis with acute apical periodontitis • post traumatic irreversible pulpitis with chronic apical periodontitis • acute apical periodontitis • periodontitis • pulp necrosis with acute apical periodontitis • fracture of endodontic tooth • post traumatic pulp necrosis with acute apical periodontitis • pericoronitis
CIFP	<ul style="list-style-type: none"> • atypical odontalgia 	<ul style="list-style-type: none"> • atypical facial pain • atypical odontalgia

Group	Sharp quality	Dull/throbbing quality
Cyst	Nil	<ul style="list-style-type: none"> infected odontogenic cysts
Neoplasm	malignant intraosseous tumours	<ul style="list-style-type: none"> malignant intraosseous tumours
Referred pain	<ul style="list-style-type: none"> referred pain 	<ul style="list-style-type: none"> referred pain

The rational for the diagnosis of pain conditions in teeth and alveolar region is similar to dental causes of pain discussed in maxilla region.

5.9.6. Hand-crafted Decision Tree of the Oral Mucosa Region

The knowledge modelling for the differential diagnosis of mucosal pain or oral disturbance of sensations depicted in the hand-crafted decision tree of Figure 5-10 A and Figure 5-10 B. Eleven rules were derived from the hand-crafted decision trees and are documented in the Appendix B.6. The decision tree leads to a differential diagnosis of oral dysaesthesia (Burning Mouth Syndrome) from other conditions as shown in the following Table 5-8.

Table 5-8: Possible conditions presenting with pain and disturbance of oral sensation in oral mucosa.

Groups	Burning pain	Stabbing/shooting pain
CIFP	<ul style="list-style-type: none"> oral dysaesthesia 	Nil
Anaemia	<ul style="list-style-type: none"> Fe deficiency anaemia B12, folate anaemia 	Nil
Candida Infection	<ul style="list-style-type: none"> acute candidiasis 	Nil
Ulceration	<ul style="list-style-type: none"> geographic tongue lichen planus 	<ul style="list-style-type: none"> apthous ulceration
Dysplasia and Carcinoma	<ul style="list-style-type: none"> mucosal dysplasia squamous cell carcinoma 	Nil
Neuropathy (primary and secondary)	Nil	<ul style="list-style-type: none"> trigeminal neuralgia glossopharyngeal neuralgia neuralgia secondary to intracranial tumour

The keys for the diagnosis of oral dysaesthesia are burning or disturbance of oral sensation with usually a normal appearance of the oral mucosa which is negative for candida infection or anaemia. The complaint is relieved by food or drink as was reported by Harris (1974), Grushka (1987), however the predictive value has never been studied. Whereas atypical odontalgia is best described as dental allodynia, oral dysaesthesia is relieved by eating/drinking or by food/drink. This distinction is baffling and may be of important aetiological significance. Although the site is different, it is unlikely that aetiological proprioceptive stimuli/taste stimuli suppress the transmission of the pain at the trigeminal ganglion of the pain in keeping with the gate theory.

The diagnosis needs to exclude the burning symptoms of other causes such as deficiency anaemias, candidiasis, lichen planus, geographic tongue, mucosal dysplasia. The diagnosis of a stabbing pain intraorally is included in the decision tree for the sake of completeness for trigeminal neuralgia.

5.9.7. Constraints of Modelling the Knowledge from the Expert

Communication between the inexperienced clinician and the expert needs time to acquire basic knowledge before effectiveness is achieved. The domain knowledge (area of expertise) has facts and underlying principles that are difficult to characterise precisely in terms of a mathematical theory or a deterministic model such as a decision tree. For example, a particular symptom, pain can be a consequence of many different mechanisms. Moreover, the history of the illness may not be accurate and needs judgement or even intuition from the clinician to validate the information. It usually requires additional investigations such as a clinical test, and imaging. These investigations can also be imprecise and need judgement from clinicians for their interpretation. The justification of some diagnoses may not be based on evidence and in some cases may be empirical. The expert uses intuition to know what information is relevant and reliable to solve problems. Thus intuition is unable to (at least for the time being) be transferred and integrated into a well structured model.

One concern of using areas of pain at a starting point in decision trees for diagnosis is when patients have several areas of pain or radiating, or referred of pain. This may lead to several diagnoses when several decision trees are triggered. In theory, these several diagnoses should have the same outcome.

The problem of poor diagnostic criteria can lead to being unable to distinguish the similar facial pain conditions as shown in the study of Pfaffenrath et al (1993). The order of clinical items of the same category may influence the diagnosis such as the quality of pain (sharp and dull pain). The question order in the decision is dependant for which the order is used as the controll knowledge part leading to the diagnosis.

The diagnosis which is based on the clinical history as a mainstay has some weaknesses due to incomplete clinical information (anamnesis), and the inappropriate selection of clinical parameters.

5.10. Conclusion

The knowledge for differential diagnosis of chronic idiopathic facial pain acquired from the expert in orofacial pain can be modelled in the decision tree format. Though the expert knowledge is empirical and subjective, it has been developed during long career of the expert by observation, analysing, synthesising from real patient cases and current literatures.

The process of knowledge acquisition is recursive in nature i.e. feed back is required for correction or refinement. Once the initial cycle comprised of identification, conceptualisation, formalisation, implementation, and testing is complete, series of refinements, redesigns, and reformulations are required until all of the requirements and elements of knowledge have been correctly identified and correctly modelled.

The advantages of the decision tree modelling of knowledge are: (1) minimum approach using reliable clinical data to deduce a diagnosis, (2) easy to comprehend. However, the disadvantage are: (1) rigidity for which there is no turning route when going the wrong way, (2) incapability to model complicated knowledge, and (3) incapability to model uncertainty in the medical data.

The decision tree can be used as a framework for generating diagnostic rules because it is convenient to check the consistency, repetitiveness of the rules by using a decision tree as a guide. The decision tree and rules are counteracted and double checking to achieve the diagnosis of pain.

In conclusion, to create a good model for expressing domain knowledge and a good frame for fitting it all together is itself a hard problem, even before one gets to the computer programming. The automated systems for acquiring domain knowledge from experts have been developed to store knowledge in an explicit form (Huang et al. 1993) that can be maintained easily by clinicians without the need to learn a programming language. Applying these new techniques to medical decision making should accelerate and produce more flexible systems that are easier to maintain.

CHAPTER 6

THE APPLICATION OF MACHINE LEARNING TO THE DIAGNOSIS OF CIFP

6.1. Introduction

Besides the expert heuristic method, a diagnostic decision tree can be induced from real clinical cases using a machine learning algorithm. Machine learning has been widely applied in medicine. The rapid growth of databases has outpaced our ability to interpret and digest data, so Knowledge Discovery in Databases (KDD) and data mining, a sub-discipline of machine learning, have been developed for automated database analysis.

The objective of this chapter is to apply machine learning techniques to the orofacial pain domain and derive a decision tree model for the diagnosis of CIFP. The chapter begins with a summary of machine learning algorithms, requirements, and associated difficulties. The decision tree learning algorithm used for inducing a decision tree is explained in detail. Then, the definition and relation between the KDD and data mining are distinguished. The process of KDD and basic data mining methods is further described. The steps in the KDD process for finding the pattern of knowledge in our patient data set are illustrated. The resulting induced decision trees for the diagnosis of CIFP are shown and discussed.

6.2. Machine Learning

6.2.1. Introduction

Machine learning is a field of computer science. It was conceived nearly six decades ago as a precursor of intelligent systems. The specific definition of machine learning emerged in 1953 with the first computational learning

experiment (Feng & Michie 1994). Machine learning is concerned with the development of computational methods that can automatically acquire knowledge by induction from examples (Mitchell 1997b). This induced knowledge enables the performance of tasks which usually need human intelligence and are generally difficult to undertake with conventional computer science technology such as database technology and software engineering. Such a form of knowledge induction is desirable in problems that lack explicit solutions, or are ill-defined. Examples are medical or technical diagnosis, visual concept recognition, or the detection of interesting patterns in large data sets. Machine learning can facilitate knowledge acquisition, a slow and laborious task often causing a bottleneck in the development of decision support systems. The practicality of machine learning serves two distinct purposes (Feng & Michie 1994): (1) as a means of knowledge acquisition in decision support systems, and (2) as a method of data analysis in databases and data mining. Machine learning has been applied widely to many fields (Langley & Simon 1997) in mechanical engineering (e.g. problem diagnosis of mechanical devices), business (e.g. the decision to issue credit cards for applicants), image and music (e.g. detecting patterns in images and music), and biomedicine (e.g. DNA analysis). Machine learning has also been used for the diagnosis and prognosis in many conditions such as cancer, liver disease, kidney disease, rheumatology, thyroid disease, skin disease, and cardiac disease. The tendency to use machine learning as a research tool is growing in the medical community.

This section gives (1) a basic background to machine learning, (2) survey of the available machine learning algorithms for diagnosis, (3) the outline of requirements for machine learning systems for medical diagnosis, (4) the discussion of issue of acceptance of machine learning in clinical practice, (5) the description of decision trees, one of the most common machine learning algorithms in diagnosis. The illustration of how the induced decision tree is constructed is documented in Appendix C.1. The features of decision tree machine learning are delineated here as a basis for the discussion of KDD and data mining (section 6.3).

6.2.2. Machine Learning Tasks

The general framework of a machine learning task is depicted in the following diagram (Figure 6-1).

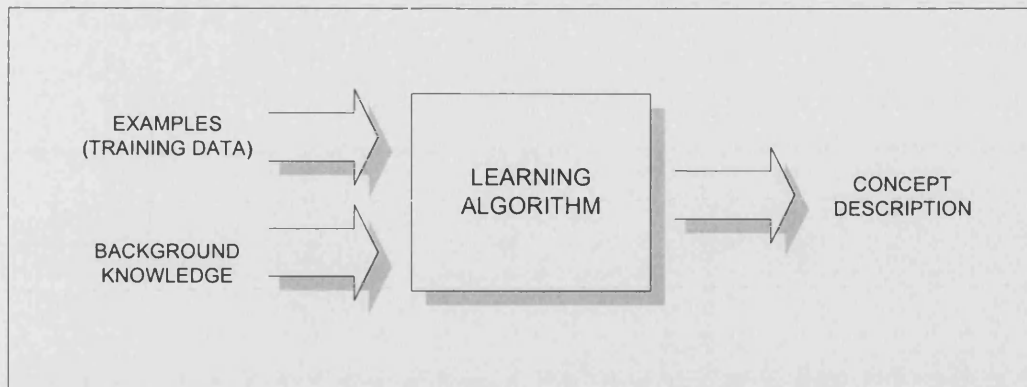


Figure 6-1: A diagram depicted machine learning tasks (Kubat, Bratko, & Michalski 1997). [re-drawn]

A system uses a learning algorithm to induce the description of a given concept from a set of examples (or training data) and from the background knowledge. For example, in a classification task, detailed examples (or training data) may be positive or negative (e.g. presence or absence of facial arthromyalgia). The “concept description” is the learned knowledge structure of the diagnosis (e.g. diagnosis of facial arthromyalgia). Background knowledge contains the information used to describe the examples. For example, background knowledge for the diagnosis of facial arthromyalgia includes clinical features that describe the patients. The learning algorithm then builds a “concept description” from the examples. Learning algorithms can be generally classified into 2 major categories: (1) black-box methods such as neural networks or mathematical statistics, and (2) transparent concept structure methods such as decision trees. In black-box methods, the details of how knowledge is encoded cannot be seen by users, and can not usually provide explanation of the result of learned knowledge. On the other hand, transparent concept structure methods create symbolic knowledge representations (or the detail of how knowledge is reached) which are explicit and potentially comprehensible to human.

6.2.3. Available Machine Learning Techniques Used in Diagnosis

Machine learning methods take four different approaches to problems of diagnosis (Lavrač 1999):

1. They can construct explicit symbolic rules or decision trees for the diagnosis, from training cases. Then, the induced rules and trees can be used to classify new cases. The machine learning algorithm that applies this approach is called rule and decision tree induction.
2. They store some of the training cases for reference, then they classify new cases by comparing them to the reference cases. A machine learning algorithm that applies this approach is called instance-based learning (also called case-based learning).
3. They can compute, for a given case, the conditional probability and assign the most probable class to the case. This is known as a naive Bayes classifier.
4. They use statistics (non-linear logistic) and a weighted sum of input attributes to determine the probability of a diagnostic class. The weight of input attributes are chosen by a learning algorithm using training cases. Then, the probability of a new case is computed, and the diagnosis class is assigned to the new case by comparing probability to the reference case. This algorithm is specific to artificial neural networks (Penny & Frost 1996).

Neural networks are one of the most popular machine learning algorithms. They have been employed in pathology and laboratory diagnoses (Finne et al. 2000), and the prognosis of critical illnesses (Demsar et al. 2001) etc. Decision tree induction is also used frequently in medical diagnosis inducing the diagnosis of myocardial infarction (Tsien et al. 1998) and otoneurological diseases (Viikki et al. 1999).

6.2.4. Requirements of the Machine Learning System for Diagnosis

Kononenko (2001) suggests the following requirements for machine learning systems for medical diagnosis:

1. Good performance

The algorithm has to be able to extract significant information from the available data. The gold standard is set as high as a physician's performance. The performance of the system is assessed, using the accuracy of diagnosis on test cases.

2. Capability to deal with missing data

Missing data is inevitable in medicine. In general, machine learning algorithms cope well with missing data.

3. Capability to deal with noisy data

Medical data is typically subjected to uncertainty and errors. The sources of noise come from:

- erroneous attribute values. Some data items are distorted for some reasons.
- misclassification. If multiple copies have been incorrectly classified, they will be contradicted in themselves.
- redundant data. When the essential attributes of a problem are not available in the training data set, the learning system tries to use other features that are normally unreliable.
- uneven distribution of data.

4. Transparency of diagnostic knowledge

The knowledge leading to a diagnosis is shown in a way that is understood by the clinician.

5. Capability to explain

The system should provide reasons for the diagnosis, such as evidence for or against supporting for each step leading to the diagnosis.

6. Reduction of the number of training data.

The cost of collecting training data examples is expensive in medicine. It is desirable to have a learning algorithm that is able to diagnose reliably with a small training data set.

6.2.5. Acceptance in Clinical Practice

Machine learning has been successfully applied in predictive models, medical signalling and imaging in clinical practice. Clinicians need help to deal with the overload of clinical data so that they can make a useful decision. However, there is resistance to such systems that aid diagnosis. The possible reasons for this are (Kononenko, Bratko, & Kukar 1997):

- Inflexibility of the knowledge representation

The information that is used by the rules to derive the final diagnosis is limited to strictly defined parameters while subjective, informal, and intuition notions cannot be represented in a formal and symbolic way. This may need to be tackled by improvement in the human cognitive-computer interface.

- In the clinical situation

Clinicians often claim superiority in that if they are not sure about the final diagnosis, further examinations (e.g. laboratory tests) may be performed to verify it. However, they are less competent with prognosis as usually there is no possibility for further examination that would confirm the prediction.

- Work load

Clinicians often claim that they are too busy to use any additional tool for decision making. It is too time consuming to type data into a computer in order to access support. This will be resolved by hard ware technology and a new generation of clinicians who can adapt to the technology.

Machine learning in clinical practice should be used as a supportive device, offering and managing clinical information. It is to be emphasised that this form of intelligent learning machine may not be used to replace clinicians-at the present time!

6.2.6. Decision Tree Learning

6.2.6.1. Introduction

Decision tree learning is a method for partitioning information, in which the learned function of the machine learning algorithm is a decision tree (Mitchell 1997a). Information used in this process is often called attribute valued. Decision trees classify a training data set by sorting from the root of the tree to some leaf node, which provides the classification or diagnoses. Each node of the tree is the clinical parameter of the case to be tested and each branch descending from the node corresponds to one of the possible values for this parameter. This process is then repeated for another parameter at a new node. Decision trees can also be re-represented as sets of if-then rules to improve their human readability. This method is among the most popular of inductive

inference algorithms and has been successfully applied to a broad range of tasks from the diagnosis of medical conditions to classifying credit risk of loan applicants. Examples of widely used machine learning decision tree algorithms are ID3 (Quinlan 1986), C4.5 (Quinlan 1993), and C5.0 (a descendant of C4.5). Decision trees can also be induced from a training data set by using statistics. One of the well-known statistics-based decision tree is the Classification And Regression Tree system (CART) (Breiman, Friedman, Olshen, & Stone 1984).

6.2.6.2. Criteria for Selecting the Best Attribute for Tree

Construction

ID3 algorithm is used as a model for studying decision tree construction. The decision trees are constructed top-down by beginning with the question “which attribute should be evaluated at the root of tree?” To answer this question, each training case attribute is evaluated at the root node using information gain measure ², a criterion based on the information theory, to determine how well it classifies the training cases. The best attribute is selected and used as the test at the root node of the tree. Then, a descendant of the root node is created for each possible value of this attribute, and the training cases are partitioned to the appropriate descendant node. The process is repeated using the training cases associated with each descendant node to select the next attribute to test at that point of the tree. Thus, building the tree is a recursive process using the information gain measure to select the best attribute at each step while it is growing. The details and an example of decision tree construction are in Appendix C.1.

The decision tree (ID3) has a preference bias as follows: (1) shorter trees are preferred over longer trees, and (2) trees that place high information gain attributes close to the root are preferred over those that do not.

6.2.6.3. Overfitting of the Data

The recursive partitioning method of constructing decision trees will continue to subdivide the set of training cases until each subset in the partition contains instances of a single class, or until no attribute test offers any improvement. The

² The information gain is the expected reduction in entropy caused by partitioning the training cases according to this attribute. Entropy is a measurement used in information theory to characterise the impurity of an arbitrary partitioning of cases. It specifies the minimum number of bits of information needed to encode the classification of an arbitrary member of a set of cases (Mitchell 1997a).

result is often a very complex tree that overfits the data. Overfitting infers more structure than is justified by the training cases. Decision tree induction is subject to overfitting in two ways: (1) when there is noise (e.g. data error) in the data, and (2) when a training set is too small to produce a representative case in the class. Overfitting is a practical difficulty of decision tree learning because it decreases the accuracy of decision trees by 10-25% when it was used to predict new cases (Mingers 1989) cited by (Mitchell 1997a).

6.2.6.4. Pruning Decision Trees

There are two basic approaches to avoid overfitting: (1) stopping or pre-pruning which stops growing the tree earlier before it reaches the point of overfitting, and (2) post-pruning which allows the tree to overfit the data, and then post-prune the tree. The post-pruning approach has been found to be more successful and reliable in practice than pre-pruning because it is very difficult to estimate precisely when to stop growing the tree in the pre-pruning approach (Quinlan 1993). The post-pruning is often validated against a test data set in term of error reduction of misclassifying cases. Pruning a decision node consists of aggregating the branches descending from that node, making it a leaf node, and assigning it the most common classification of the training cases within that node. Nodes are then tested with the validation test set. Pruning of nodes stops when it decreases accuracy of the tree over the validation test set.

6.3. Knowledge Discovery in Databases and Data Mining

6.3.1. Introduction

The term “data mining” and “Knowledge Discovery in Databases (KDD)” are often used interchangeably. In general, data mining is often used as the synonym for extracting useful patterns from databases. The term data mining originated in statistics. The term KDD was coined later in the computer science to emphasis that “knowledge” is the goal of data analysis process. Fayyad et al. (1996) defined them as follows:

‘Data mining refers to specific application of algorithms for extracting structures (or patterns or relationships) from data’.

Knowledge discovery refers to the process encompassing the entire data analysis lifecycle (including identification of goals, acquisition and

organisation of raw data, and generation of useful knowledge), its interpretation, and its testing.'

Therefore, data mining is limited to a step in KDD, while KDD extends beyond data analysis to validation and interpretation of the patterns which are found. KDD is a new interdisciplinary field lying in the intersection of machine learning, statistics, data management and databases, pattern recognition, artificial intelligence, visualisation, optimisation, high-performance and parallel computing (Bradley, Fayyad, & Mangasarian 1999). Data mining and KDD typically deal with large data sets that have already been collected for some purposes other than data analysis. For example, data may have been collected for the up-to-date records of all transactions in a bank. In real-world problems, commercial businesses are at the forefront of the adoption of data mining and KDD being increasingly employed in other fields such as biomedical field.

The objective of this subsection is twofold: (1) to provide a basic view on data mining and KDD, (2) to present our work on inducing diagnostic knowledge patterns from the patient data set of CIPF from the EEPP database.

6.3.2. The Steps of Knowledge Discovery in Databases

The designs of the processing steps that assist practitioners to conduct knowledge discovery projects have been well established. The well-designed concise six-step model of Cios and Moore (2002) is described here as follows:

1. understanding the problem domain
2. understanding the data
3. preparation of the data
4. data mining
5. evaluation of the discovered knowledge
6. using the discovered knowledge

The additional steps from the data mining step such as prior knowledge of problem domain and data details, data preparation, evaluation, and interpretation of the results from data mining, are essential to ensure that the useful knowledge is derived from the data. Blind performance of data mining can lead to the discovery of meaningless patterns.

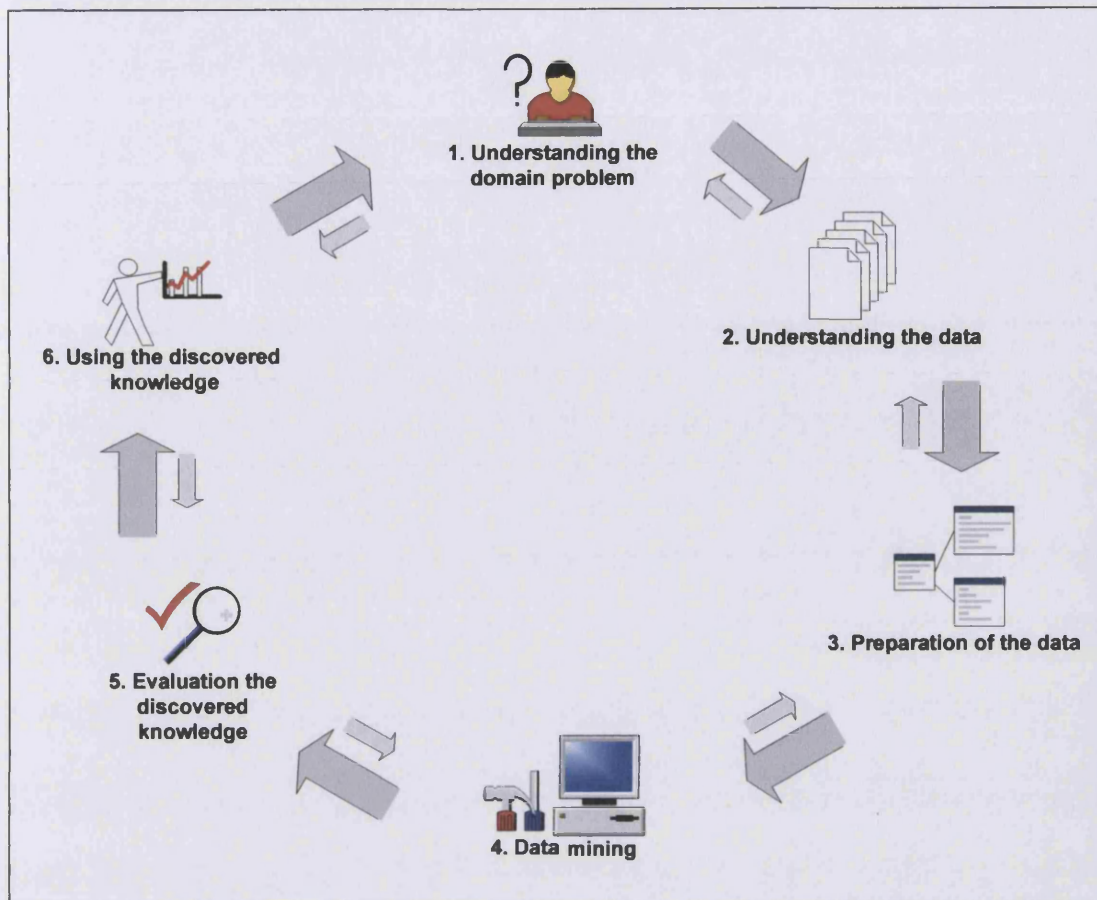


Figure 6-2: The steps of KDD (modified from Cios and Moore 2002). The big arrow is an algorithm and the small arrow is the feedback to previous stage.

Figure 6-2 illustrates the interactive process of KDD where change in one step can affect the other steps. During each process, there are experimental trials to be done. For example, one may select patient cases, sampling the cases for training and testing, reject irrelevant attributes, aggregate where necessary and then find from the results that some previous steps need to be redone. This six-step model is employed to explain the KDD process for the diagnosis of CIFP.

6.3.3. Step 1: Understanding the Domain Problem

CIFP which includes facial arthromyalgia, atypical facial pain, atypical odontalgia, and oral dysaesthesia, is a condition which is difficult for some to diagnose. The diagnosis is dependent on the pain history since no confirmatory laboratory test has been established. The pain history can be complicated and need to be systematically and skilfully approached to elicit the essential clinical information from the patient. This difficulty can lead to incompleteness in the data essential for the diagnosis.

6.3.4. Step 2: Understanding the Data

Understanding the relevant attributes is essential for data mining and the interpretation of the results. This can help to avoid using unreliable attributes. The data set of patients in the EEPP database is described.

6.3.4.1. The Nature of Medical Data

Medical data can be collected from the clinician-patient interview (history taking), imaging, laboratory data, and clinicians' interpretative scripts in the medical record. The data is heterogeneous since it is composed of text, images, and biosignals (like ECG). The history data is anamnestic (from memory) and is prone to error. Computerised data cannot be used seamlessly it consists of heterogeneous of terminology, vocabulary, and format. The data is also often incomplete with missing parameters, values, and anamnesis. Data errors in the decision support system or random noise in data and inappropriate selection of parameters are also problems. The data can also be sparse because of few or non-representative patient records.

6.3.4.2. The Patient Data from the EEPP Database

A data set of 308 patients who were referred to the Facial Pain Clinic, of the Department of Oral and Maxillofacial Surgery at the Eastman Dental Hospital during July 1998 to March 2002 was used in this study. The study is divided into 2 periods, the pilot study during July 1998 to October 1998 and the subsequent study period during February 1999 to March 2002. The eligible patients are aged 18 and over, who could communicate using English and who were referred to the clinic for chronic facial pain for the first time, or patients who were referred for the second time having been symptom free for a period of time. Table 6-1: The diagnosis distribution in the data set used for inducing the decision tree

Table 6-1: Distribution of diagnoses in patient data set

Diagnosis	Frequency
Facial arthromyalgia	173
Atypical facial pain	45
Atypical odontalgia	28
Oral dysaesthesia	16

Diagnosis	Frequency
TMJ disc displacement with reduction (pain free)	18
Osteoarthritis of TMJ	9
Trigeminal neuralgia	3
Hybrid atypical facial pain and trigeminal neuralgia	4
Pulpitis	5
Periapical abscess	2
Periodontitis	2
Facial migrainous neuralgia	1
Migraine	2
Tension headache	1
Anaemia	1

Within this distribution, 6 patients have facial arthromyalgia in combination with other diagnoses i.e. 1 patient with periodontitis, atypical odontalgia, and osteoarthritis, 2 patients with migraine headache, and 3 patients with pulpitis. Four patients have atypical facial pain in combination with other diagnoses i.e. 1 patient with facial migrainous neuralgia, and 3 patients with oral dysaesthesia. The history taking used a standard format for pain patients and consists of history, examination, diagnosis, and treatment. The history and examination were assisted by using paper-based Facial Pain Proforma (FPP) which was developed and tested with the facial pain patients at the Eastman Dental Hospital. The full history data falls into 6 distinct categories:

- administrative data,
- demographic data,
- pain history data,
- present and past medical history data,
- psychosocial history data, and
- family data

The full examination data falls into 7 distinct categories:

- cranial nerve examination data,
- extra-oral examination data,
- TMJ examination data,
- muscle examination data,
- teeth examination data,

- oral mucosal examination data, and
- radiographic and laboratory examination data

Details of the questionnaire are to be found in the Appendix A.1. The clinical data were entered and stored in the Electronic Eastman Pain Proforma (EEPP), the electronic version of the FPP implemented in the commercial database software, Microsoft Access 97. Part of the data (55 patients) was collected directly by the EEPP by 5 clinicians during the assessment of the EEPP. Access employs a relational database management system, in which the data are stored as attributes in multiple tables joined by linking attributes.

6.3.5. Step 3: Preparation of the Data

Data preparation is a time-consuming and labour-intensive procedure, but is absolutely necessary for successful data mining. The process is not achieved in one step leading to the data mining step. It is an interactive process both forwards and backwards (i.e. iterative) and needs feedback from the data mining step, evaluation, and interpretation of the discovered knowledge as seen in Figure 6-2. This task receives little attention in the research literature. The machine learning technique using data mining can be compared to the capability of the chef to process all the ingredients for a good quality dish. How can one get a good quality dish, if the raw ingredients are not in a well-prepared format? The application of data mining in a real world situation requires more effort spent on preparing the data than applying the machine learning technique to induce a knowledge model. The major aims for the preparation of the data are: (1) to organise the data into a standard form that is ready for processing by machine learning techniques, (2) to prepare the features that lead to the best predictive performance. The consequent advantages are:

- the reduction of the computational cost because the attribute input is decreased.
- a potential increase in the interpretability of the model; Models with fewer attributes are more understandable.
- a reduction of overfitting in the model; Overfitting results from excessive partitioning of the data leading to many small irrelevant groups.

6.3.5.1. Standard Format for Data Mining

The algorithms, in data mining software, are based on a single table, within which there is a record for each individual. An individual record consists of fields (also called attributes or variables or columns) containing values specific to that individual. The most convenient format for the data mining data table is a flat file, with one line for each individual record. The details are to be founded in Appendix C.2.

6.3.5.2. Preparation of the Data in the EEPP Database

In this study, a key component is data transformation from the relational structure of the Access database, which stores the data in multiple tables, to a standard form suitable for data mining. This section describes the data transformation from the Access database into a single flat file. ,

In the relational database, clinical data was stored in multiple tables to promote the efficiency and convenience for retrieving and storing the data. However, its format is not suitable for data analysis in a data mining software which requires a single table. Therefore, the clinical data must be assembled and integrated into a record for each individual patient. The Structured Query Language (SQL) which is a programming language exclusively for database management was employed for manipulating the data such as retrieving, and organising data under desirable conditions. Details of SQL are to be found in Appendix C.2.

The following Table 6-2 shows the attribute transformation from the EEPP database fields to the data mining table fields. Table 6-2 represents only a part of all attributes in the EEPP database which have to be transformed to the data mining table. Column 1 indicates data groups within EEPP database. Column 2 indicates the attributes in that table. Column 3 indicates transformed attributes within the data mining data table. The data mining data table has 289 records (rows) and 117 attributes (columns). Of the 117 attributes, nearly all of them have categorical values. Those with numerical values include:

- age in years
- duration pain in years
- number of covered pain areas,
- number of pain muscles,

- number of problems,
- maximum opening.

The majority of categorical attributes have binary values (0= absent/no or 1= present/yes). Other categorical attributes contain nominal (different characteristics e.g. pain, clicking, locking etc.) and ordinal values (e.g. degrees of severity) including:

- sex (0=female, 1= male)
- distribution (unilateral, bilateral)
- daily pattern (morning, afternoon, evening, night)
- localised/diffuse (localised, diffuse)
- sleep disturbance (nil, disturb, wake up)
- main complaint
- other complaint 1
- other complaint 2
- other complaint 3

The main complaint and other complaints comprise of 10 possible values – “pain”, “clicking or crepitus”, “limited mouth opening”, “sticking or locked jaw”, “TMJ dislocation”, “disturbance of oral sensation”, “headache”, “tinnitus”, “taste change”, “bite discomfort”.

Table 6-2: Transformed attributes for data mining

Attribute Groups	EEPP Database Field	Data Mining Data Table Field	Descriptions
Administrative data	Visit Identity (Visit ID)		For record linking
Demographic data	Pt Identity (Pt ID)	Pt ID	PtID is a record number 1, 2, 3, ..., n.
	Hosp. Nos.		Patient Identifier is removed.
	Name		Patient Identifier is removed.
	DOB	Age	Transform DOB to ages in year as of 1 January 2001.
	Sex	Sex	Sex of patients
	Marital Status	Marital Status	Marital status of patients
Pain history data	PainHistory ID		For record linking
	Visit ID		For record linking
	Main Complaint	Main complaint	These attributes include MainComplaint, OtherComplaint1, OtherComplaint2, OtherComplaint3 having categorical values such as pain, limited opening, disturbance of oral sensation.
	Other Complaint 1	Other Complaint 1	
	Other Complaint 2	Other Complaint 2	
	Other Complaint 3	Other Complaint 3	
	Duration in Years	Duration in Years	Duration in years of pain since onset.
	Site Distribution	Site Distribution	What is pain distribution? (left, right, bilateral)
	Quality 1	Dull ache	Is the quality of pain dull-ache? (yes, no)
	Quality 2	Sharp/stabbing	Is the quality of pain sharp/stabbing? (yes, no)
	Quality 3	Burning	Is the quality of pain burning? (yes, no)
	Quality 4	Throbbing	Is the quality of pain throbbing? (yes, no)
		Tingling	Is the quality of pain tingling? (yes, no)
		Electric-liked	Is the quality of pain electric-liked? (yes, no)
	Diffuse/localised	Diffuse/localise	Is pain diffuse or localised? (diffuse, localised)
	Intensity	Intensity	What is pain intensity? (mild, moderate, severe)
	Sleep Disturbance	Sleep Disturbance	Does pain disturb sleep? (nil, disturb, wake up)

Attribute Groups	EEPP Database Field	Data Mining Data Table Field	Descriptions
Modifying factors data	Episode Length	Episode Length	How long of each episode of pain? (seconds, minutes, hours, days, weeks, months)
	Episode Frequency	Episode Frequency	How frequent of episode of pain? (every second, minutely, hourly, daily, weekly, monthly, yearly)
	Daily Pattern	Daily Pattern	What is daily pattern of pain? (morning, afternoon, evening, night)
	Progress	Progress	What is the progress since onset? (same, better, worse)
	PainHistory ID Current aggravating factors (CAF) codes	All current aggravating factors values are transposed to be attributes in the data mining table. Examples of CAF are hot food/drink, cold food/drink, bite/chew, jaw move, bending head.	For record linking What does make pain worse? All aggravating factors fields in data mining data table have yes/no value.
Face pain areas data	PainChart ID PainHistory ID Pain areas are divided to maxilla, mandible, TMJ, ear, frontal, temple, vertex, occipital, neck. Areas are subdivided to left, right, front, lateral and link to the face diagram. For example, left front maxilla, left lateral maxilla.	Maxilla Mandible TMJ Ear Temple Frontal Supraorbital Infraorbital Vertex	For record linking For record linking Is pain in maxillas? Is pain in mandibles? Is pain in TMJ? Is pain in ears? Is pain in temples? Is pain in frontal? Is pain in supraorbital? Is pain in infraorbital? Is pain in vertex?

Attribute Groups	EEPP Database Field	Data Mining Data Table Field	Descriptions
Examination data	Cranial nerve examination Identity (CNExamID) Visit ID Cranial nerve examination Findings	Occipital Neck No. of covered area All positive finding are transposed to be attributes in data mining data table.	Is pain in occipital? Is pain in neck? Number of all pain areas (including left, right, frontal, lateral) as coded in FPP database For record linking For record linking All findings fields in data mining data table have yes/no value.
Radiographic data	Radiographic ID Visit ID Radiographic techniques Locations Sites Findings	 All findings are transposed to be attributes in data mining data table.	For record linking For record linking For patient management For patient management For patient management These variables are yes/no type variables.

6.3.6. Step 4: Data Mining

Data mining step is the heart of the entire KDD process. It is a step where hidden patterns and trends in the data are uncovered. Many algorithms have been developed for discovering patterns in the data including regression analysis, k-nearest neighbour, naive Bayes classifier, decision tree, and artificial neural networks. In this section, the criteria for selecting the technique for data mining and the software are discussed. Then, the methods of data mining are explained.

6.3.6.1. Selecting the Data Mining Algorithms

A range of techniques from both machine learning and statistics have been developed to extract the knowledge in data mining step. One of the aims of creating an induced decision tree for the diagnosis of chronic idiopathic facial pain is to compare its performance with a hand-crafted decision tree acquired from the expert. Transparency of the structural pattern of the information processed is an important criterion for selecting the technique. Transparent knowledge is much more acceptable and comprehensible to clinicians. Also a transparent knowledge decision tree can be used in training novice health practitioners. Thus, the decision tree algorithm technique of machine learning was chosen.

In the machine learning community, there is a diversity of decision tree algorithms for inducing decision trees automatically from data sets. The best known of these are ID3 (Quinlan 1986), C4.5 (Quinlan 1993), ASSISTANT (Cestnik, Kononenko, & Bratko 1987) cited by (Lavrač 1999) and its variances (ASSISTANT-R and ASSISTANT-R2) (Kononenko & Simec 1995) cited by (Lavrač 1999). Here, C5.0, the commercial descendant of ID3 and C4.5, is used to induce decision tree classification models for chronic idiopathic facial pain.

Comparison studies on the performance of the decision tree on a variety of diagnostic tasks have indicated that its performance in terms of accuracy can compete with other techniques and its accuracy was not significantly different to those of clinicians (Kukar et al. 1999; Mani et al. 1999; Rudolfer, Paliouras, & Peers 1999; Tsien, Fraser, Long, & Kennedy 1998). Nevertheless, other studies indicated opposing results (Zelic et al. 1997) (Dreiseitl et al. 2001). The different

results of performance may be depend on many factors including complexity and type of domain problems, and sample size of training cases. Other attractive properties of induced decision trees are (Hand, Mannila, & Smyth 2001):

- ability to handle mixed attributes such as categorised, continuous, and real number attributes.
- rapid prediction of the class value for a new case.
- handling of missing and noisy data.

6.3.6.2. Selecting the Data Mining Software

There are many commercial data mining software suites (programmes) which support machine learning techniques, in particular the decision tree technique. In fact, decision tree construction is a primary function provided in general-purpose data mining software suites. The performance of software can be measured from functionality, programmability, efficiency, user-friendliness, visual support, database integration support, and price. There is no objective study comparing commercial software suite performance in the literature; it may reflect that this kind of study is not the straightforward task as it looks. The best examples of commercial data mining software suites are Clementine (SPSS Inc.), See5 (Rulequest Research), and CART system (Salford system). Clementine supports a range of machine learning techniques, including decision tree and rule induction algorithms based on C5.0. Clementine has visual programming interfaces. The details of Clementine are to be found in Appendix C.3.

6.3.6.3. Training and Testing

C5.0 generates decision trees by learning from known classification training cases. The result is a learning model of the diagnostic pattern CIPF. The result also provides the induced decision tree performance factors such as accuracy, or an error rate. The performance of a learning model is usually optimistic because it is calculated by resubstituting the training cases into a decision tree classifier that was constructed from them. Therefore, it is incorrect to assume that the performance of this learning model led on the training data represents the level of performance that can be expected on unseen data to which the

learned model will be applied in practice. Moreover, the capability of the algorithm in recursively partitioning the tree could reach to the point of perfect purity which could sometimes gain only one case in a terminal node; this is called overfitting. This overfitted decision tree does not help in accurately classifying independent unseen cases.

To assess the performance of a learning model, the training and testing approach is introduced. The essential idea is that - a sample of data (the training data) is given to enable an induced diagnostic decision tree to be set up. The induced diagnostic decision tree is then tested on a second independent sample of new known observations (the test data). The motivation is that the test data can be expected to provide a safety check against overfitting and irregularity of the induced diagnostic decision tree. Moreover, the evaluation against independent cases gives an unbiased estimation.

There are three main variants of the training and testing approach based on the sample size of data (Henery 1994). In this study, the size of samples is moderate (280 cases), therefore the n -fold cross-validation method is adopted. To supply a sufficient number of cases from each diagnostic group into each partition, the methods called 5-folds cross-validation and stratified blocked randomisation are applied to the data. The CIFP data set are partitioned into 5 main groups discarding other small diagnostic groups. The 5 main groups are:

- facial arthromyalgia (173),
- atypical facial pain (45),
- atypical odontalgia (28),
- TMJ disc displacement with reduction (pain-free clicking) (18),
- oral dysaesthesia (16).

To gain a reliable estimation of accuracy, 10 runs of 5-folds cross-validation are operated. The details are described in Appendix C.4. This is based on the rationale that each different fold produces different results because of the effect of random variation in choosing the folds themselves (Witten & Frank 2000). Furthermore, the training data set is a sample of diseased patients, not the whole population of those who have ever had the disease. Repeated randomisation among different batches of patients is bound to generate different estimates of accuracy (Sackett et al. 2000). The results of 10 runs of 5-

folds cross-validation can create many induced decision trees, so that the other advantage is to use as a means of selecting better induced decision trees.

The performance of the induced decision tree is then assessed using the accuracy rate, sensitivity, specificity, and likelihood ratio from the unseen test cases with known diagnoses, and compared with the human performance.

6.3.6.4. Setting the Conditions and the Resulting Accuracy of Induced Decision Trees

Before the induced decision tree is generated, the software conditions are adjusted to enhance the performance. They are adjusted for overfitting of decision tree structures.

1. Adjusting for Overfitting

Software conditions can be adjusted to reduce overfitting by adjusting the severity of pruning.

Table 6-3: Effect of pruning on the accuracy of induced decision trees

Pruning severity (%)	Mean training accuracy (95%CI)	Mean test accuracy (95% CI)
1	92.0% (89.2-94.9)	67.8% (61.4-74.1)
10	93.5% (92.6-94.3)	66.1% (61.7-70.5)
19	93.5% (92.6-94.3)	66.1% (61.7-70.5)
28	93.5% (92.6-94.3)	66.1% (61.7-70.5)
37	92.6% (91.7-93.5)	67.4% (61.6-73.3)
46	92.7% (91.7-93.6)	67.8% (61.8-73.8)
55	92.5% (91.4-93.6)	67.4% (61.5-73.4)
64	92.0% (90.7-93.2)	67.8% (61.3-74.2)
73	91.8% (90.9-92.7)	67.0% (60.4-73.4)
82 *	87.0% (83.9-90.1)	71.4% (65.7-77.0)
91	86.5% (83.5-89.6)	71.0% (65.6-76.4)
99	78.6% (74.3-82.9)	70.0% (64.1-75.9)

* Value of prune severity which gives the highest mean test accuracy

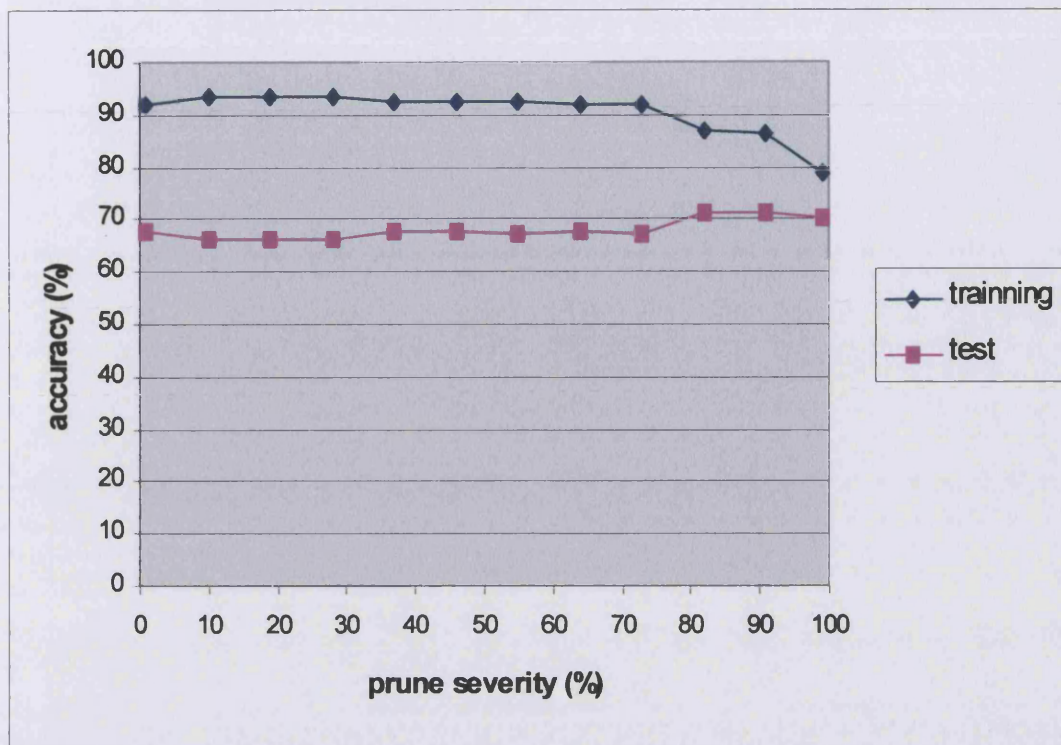


Figure 6-3: Effect of pruning on the accuracy of induced decision trees. The highest accuracy (71.4%) on test cases is obtained when the prune severity is 82%. At the point of test accuracy reach optimum, the training accuracy begins to decrease.

From Table 6-3 and Figure 6-3, it is shown that mean test accuracy of induced decision trees reaches optimum at 71.4% when adjusting the pruning severity to 82%, with a 95% confidence interval from 65.7% to 77.0%. Therefore, this degree of pruning was applied to generate the induced decision trees. In addition, Table 6-3 demonstrates that the accuracy of induced decision trees on the training set is optimistic. When the induced decision trees were tested on independent test sets, their accuracy dropped.

2. Average Accuracy of the Induced Decision Trees

Results from trial experiments of data mining have shown that induced decision trees excluding topographic pain areas had more comprehensible although the accuracy were lower than when including the areas. Also decision trees which were induced by adjusting noise gave a more accurate performance than those without adjusting noise. Therefore, we decided to induce decision trees;

- with all clinical data and include topographic pain areas
- with all clinical data but excluding topographic pain areas

- with 5% noise adjustment of the software to compensate noise in the data
- without noise adjustment

Within the conditions 1 and 2, we tested the effect of 5% noise adjustment (condition 3) and without noise adjustment (condition 4). The average accuracy performances of each condition were assessed 50 decision trees resulted from 10 runs of 5-folds cross-validation (Table 6-4). The results of experiments (a) and (b) are summarised as follows:

(a). Experiment with pain area and without pain area

Table 6-5 indicates that accuracy of induced decision trees improve nearly 10% when the pain area is included. However the induced decision tree structure is very brief and may be too crude to be applied to a real case.

(b). Effect of compensation of noise in the analysis

Table 6-6 indicates that the accuracy of induced decision trees improves about 2% with 5% noise adjustment. This compensation of 5% noise adjustment seems to yield the optimal accuracy and the tree seems to have appropriate to be applied to clinical cases.

Table 6-4: Mean accuracy of the induced decision tree on testing data set (unseen cases) from 10 runs of 5-folds cross-validation

Run	without pain area		with pain area	
	0% adjusted noise (95%CI)	5% adjusted noise (95%CI)	0% adjusted noise (95%CI)	5% adjusted noise (95%CI)
1	68.8% (65.8-71.8)	72.4% (68.2-76.5)	78.9% (77.6-80.1)	80.6% (76.9-84.4)
2	68.8% (64.4-73.3)	71.3% (66.5-76.1)	77.0% (72.9-81.2)	80.7% (74.9-86.6)
3	68.8% (65.6-72.0)	70.3% (67.4-73.1)	79.6% (75.4-83.8)	81.7% (78.2-85.3)
4	67.9% (61.9-73.9)	71.5% (64.4-78.6)	81.4% (77.9-84.9)	82.1% (79.2-85.1)
5	69.9% (67.8-72.0)	71.3% (68.0-74.6)	78.1% (70.1-86.1)	79.2% (72.4-85.9)
6	66.3% (62.5-70.1)	68.9% (61.4-76.4)	78.5% (74.9-82.1)	80.3% (75.8-84.8)
7	70.5% (65.0-76.0)	72.7% (68.0-77.3)	77.4% (71.7-83.0)	81.3% (76.4-86.3)
8	72.7% (65.4-80.1)	72.0% (65.9-78.1)	78.8% (75.9-81.8)	79.2% (75.6-82.8)
9	70.4% (66.3-74.4)	72.2% (67.8-76.5)	78.4% (74.8-82.1)	83.1% (79.8-86.3)
10	68.8% (65.6-72.0)	71.3% (67.5-75.2)	80.7% (76.1-85.4)	81.1% (76.2-86.0)
Mean accuracy	69.3% (67.4-70.7)	71.4% (69.9-72.9)	78.9% (77.6-80.2)	80.9% (79.6-82.3)

Note: Each run of 5-folds cross-validation produced 5 decision tree models, therefore accuracy corresponding to order of run is mean accuracy with a 95% confidence interval (95%CI) of 5 decision tree models. Mean accuracy at the last row is total mean accuracy of all 50 decision tree models generated from 10 runs.

Table 6-5: Comparison of the improvement of mean accuracy by including the topographical pain areas

0% adjusted noise			5% adjusted noise		
without pain area (95%CI)	with pain area (95%CI)	improvement (95%CI)	without pain area (95%CI)	with pain area (95%CI)	improvement (95%CI)
69.3% (67.4-70.7)	78.9% (77.6-80.2)	9.6% (8.1-11.1)	71.4% (69.9-72.9)	80.9% (79.6-82.3)	9.6% (7.9-11.2)

95% CI : 95% confidence interval of value

Table 6-6: Comparison of the improvement of mean accuracy by adjusting noise

without pain area			with pain area		
0% adjusted noise (95%CI)	5% adjusted noise (95%CI)	improvement (95%CI)	0% adjusted noise (95%CI)	5% adjusted noise (95%CI)	improvement (95%CI)
69.3% (67.4-70.7)	71.4% (69.9-72.9)	2.1% (1.0-3.1)	78.9% (77.6-80.2)	80.9% (79.6-82.3)	2.0% (1.3-2.8)

95% CI : 95% confidence interval of value

6.3.7. Step 5: The Evaluation of the Discovered Knowledge

6.3.7.1. General Considerations

A total of two hundred induced decision tree models were generated under the conditions as previously described. All models were inspected. The structure of the induced decision tree model generated by Clementine is illustrated in Figure 6-4.

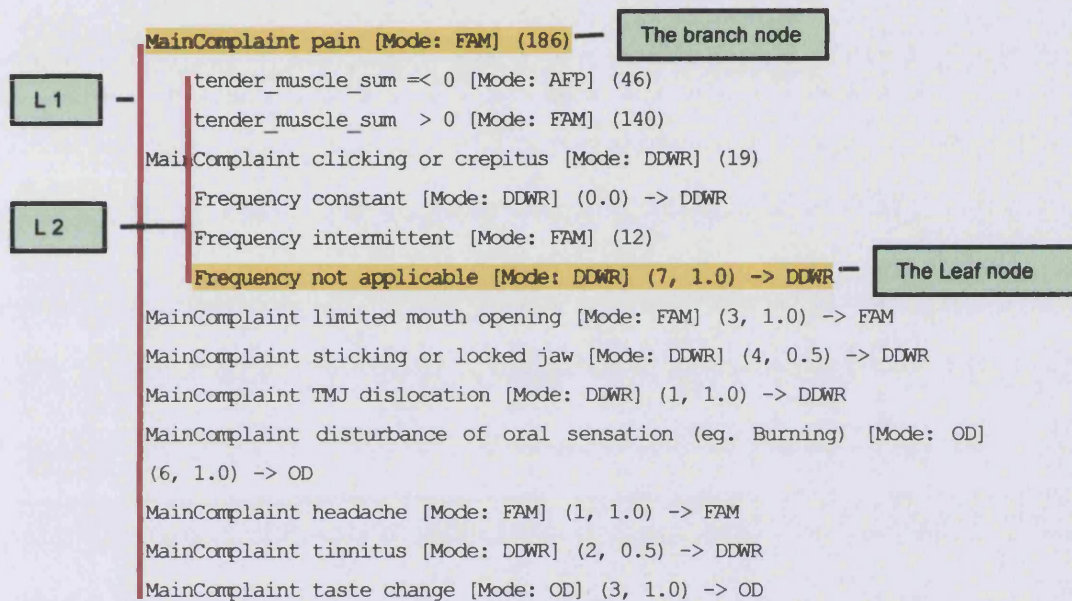


Figure 6-4: The structure of an induced decision tree generated by Clementine. L1= Level 1 of branch; L2 = Level 2 of branch. FAM = facial arthromyalgia; AFP = atypical facial pain; DDWR = TMJ disc displacement with reduction; OD = oral dysaesthesia.

The induced decision tree structure is arranged in the horizontal direction with different level of nodes (Figure 6-4). A branch node is a node for which its attribute is to be evaluated whereas a leaf node or a terminal node is a node for which the induced decision tree reaches the diagnosis. The following Figure 6-5 is the illustration of the branch node and its descendant nodes. This branch node is to evaluate the value “clicking or crepitus” of the attribute “Main Complaint”. The bracket after the attribute value indicates the mode of cases which fall in this node. The number after the mode is the number of cases reaching this node. This branch node consists of 3 descendant nodes for which

the test attribute is “Frequency” (frequency of pain) which has 3 values i.e. “constant”, “intermittent”, and “not applicable”.

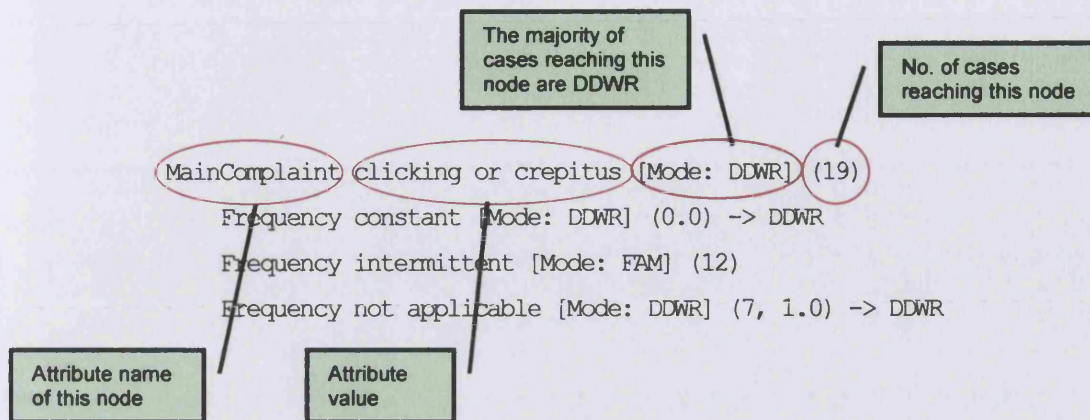


Figure 6-5: The illustration of the branch node and its descendant nodes from the induced decision tree Figure 6-4.

The descendant node with value of “not applicable” is the leaf node or the terminal node because the induced decision tree reaches to the diagnosis of DDWR with 7 cases falling into this leaf node and all 7 cases are true for this diagnosis (or confidence = 1.0) (see Figure 6-6).

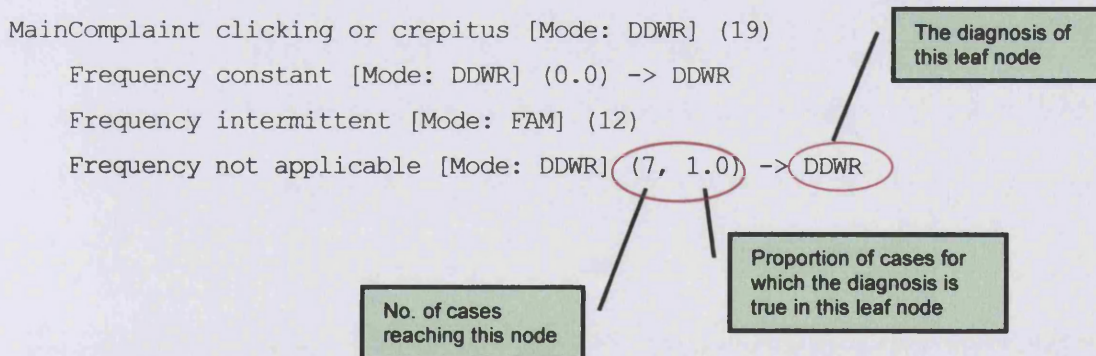


Figure 6-6: The illustration of the leaf node of the induced decision tree.

The range of the results of knowledge patterns for the diagnosis of CIFP varied. Some part of the induced decision tree diagnosis conformed with the human diagnosis. However some exhibited predictors which were of doubtful value for diagnosis.

In the models excluding topographical pain areas, 83 attributes from 117 input attributes were used for classification for all 50 induced decision tree models of 10 runs of 5-folds cross-validation. The range of 7 to 19 attributes (mode = 13 attributes) and 5 to 11 branch levels (mode = 7 levels) presented in an induced decision tree model. Figure 6-7 shows 20 attributes which scored in the top twenty from 99.6% to 10.4%. The details of the scoring method which based on the rank and frequency of the attribute appearing in induced decision trees are described in Appendix C.5. Another 22 attributes scored in the range 9.6% to 5.1%, and the majority (41 attributes) have a poor score in the range 4.9% to 0.2%. Root nodes at the first level are more important (based on information gain ratio of its algorithm) than nodes in lower levels.

In the models including topographical pain areas, 65 attributes from 117 input attributes were used for classification. Figure 6-8 shows 20 attributes which score in the top twenty in the list, these range from 100% to 6.3%. Generally, the induced decision tree model generated by including topographical pain areas places the pain area at the root node. Moreover, the branch level is less than those generated by excluding topographical pain areas. The branch level varies from 4 to 8 levels (mode = 5 levels), and the attributes in each induced decision tree model varies from 8 to 14 attributes (mode = 9 attributes). It is noticeable that the overall accuracy of induced decision trees generated by including pain areas is higher than the others (Table 6-6). To include pain areas may lead to a more correct differential diagnosis of atypical facial pain from atypical odontalgia because these two diagnoses are almost identical except for the location of pain. Table 6-7 illustrates the attributes often presenting in the top 4-level of induced decision trees generated by excluding and including topographical pain areas.

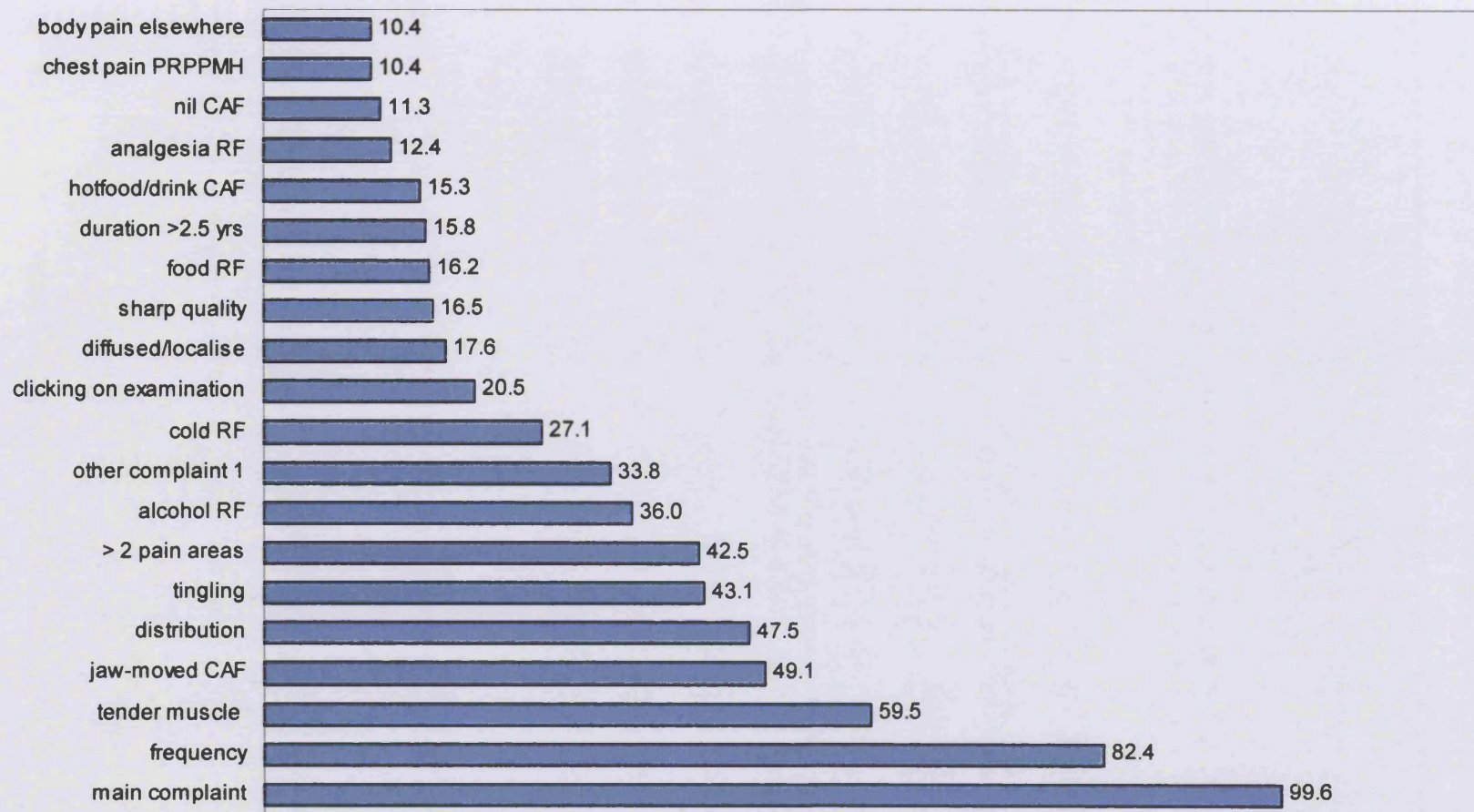


Figure 6-7: Attributes and their percentage ranking in the top twenty score list of the induced decision tree excluding the topographical pain areas. CAF = current aggravating factors, RF = relieving factor, PRPPMH = present and past pain medical history. Method of scoring is explained in appendix page.

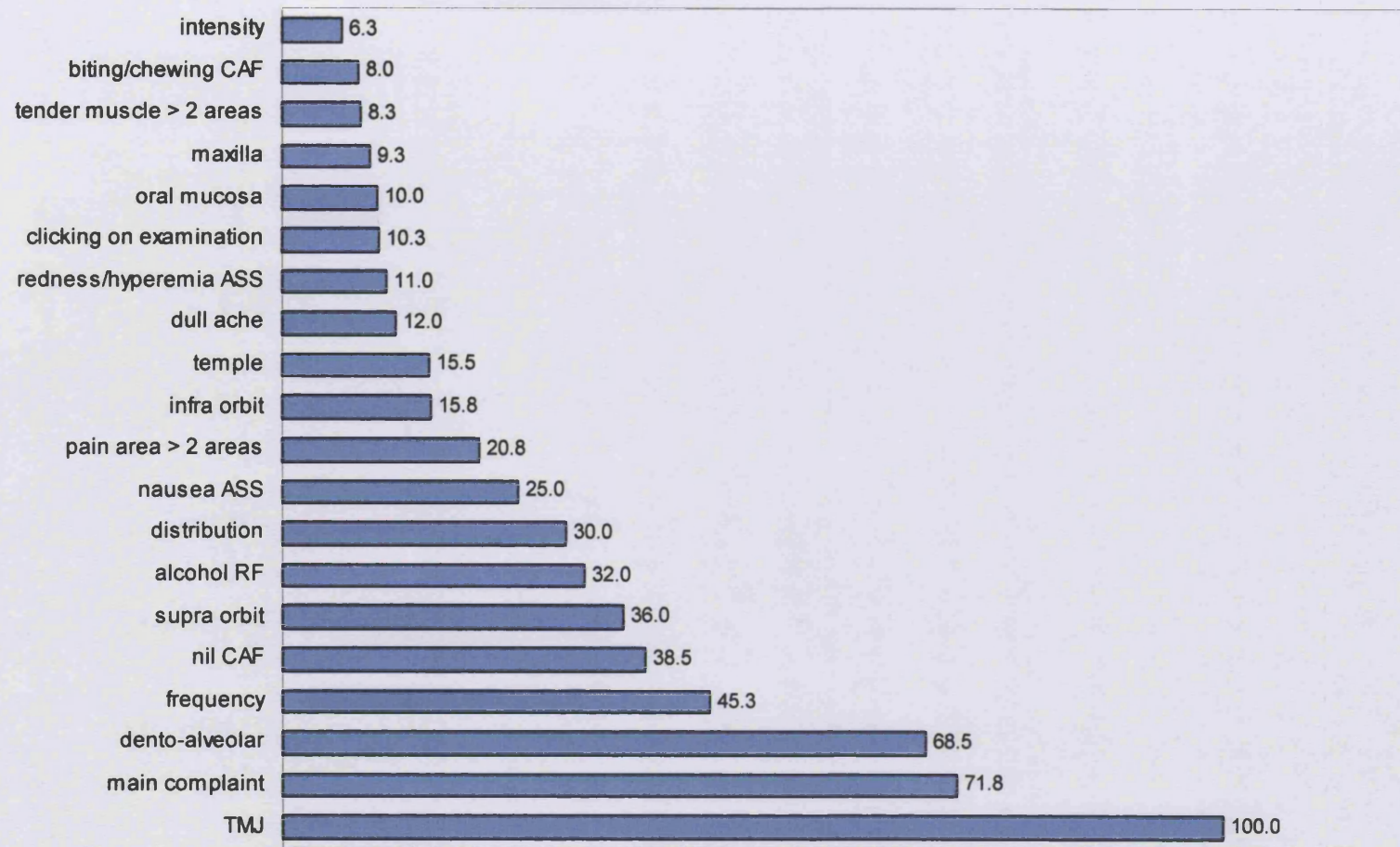


Figure 6-8: Attributes and their percentage ranking in the top twenty score list of the induce decision tree including the topographical pain areas. CAF = current aggravating factors, RF = relieving factor, PRPPMH = present and past pain medical history. Method of scoring is explained in appendix page.

Table 6-7: Comparison of attributes in the top 4-level nodes of the induced decision tree with topographical pain areas excluded and included.

Level Node	Models excluding pain areas	Models including pain areas
1	main complaint <ul style="list-style-type: none"> • pain • clicking or crepitus • limited mouth opening • sticking or locked jaw • TMJ dislocation • disturbance of oral sensation • headache • tinnitus • taste change • bite discomfort 	TMJ (yes, no)
2	frequency of complaint (constant, intermittent, not applicable) tender muscle areas > 0 sites jaw-moved CAF (yes, no) distribution (unilateral, bilateral) sharp quality of pain (yes, no)	main complaint <ul style="list-style-type: none"> • pain • clicking or crepitus • limited mouth opening • sticking or locked jaw • TMJ dislocation • disturbance of oral sensation • headache • tinnitus • taste change alcoholRF (yes, no)
3	distribution (unilateral, bilateral) other complaint 1 <ul style="list-style-type: none"> • pain • clicking or crepitus • limited mouth opening • sticking or locked jaw • TMJ dislocation • disturbance of oral sensation • headache • tinnitus • taste change • bite discomfort alcohol relieving factor (yes, no)	dento-alveolar (yes, no) frequency of complaint (constant, intermittent, not applicable)
4	pain areas > 2 areas tingling (yes, no)	nilCAF (yes, no) distribution (unilateral, bilateral) pain areas > 2 areas

6.3.7.2. Analysis of the Discovered Knowledge

Of the 100 induced decision tree models generated (50 with excluded topographical pain areas and 50 with included topographical pain areas) from 10 runs of 5-folds cross-validation, those with accurate performance and comprehensibility were selected for analysis. In general, induced decision trees

can be discussed in terms of those confirming current medical opinion, those challenging it, and those which raise issues to be resolved (McQuatt et al. 2001). The agreement of the induced models with the human diagnosis is analysed using kappa statistics (Friedman & Wyatt 1997b). The diagnostic performance is also analysed using sensitivity, specificity, positive predictive value, negative predictive value, and positive/negative likelihood ratio (Altman 2000). There are 6 interesting models for which two, with and without topographical pain areas are discussed in the following, and the rest are documented in Appendix C.7.

Model 1

This induced decision tree is an example of induced decision trees trained by excluding the topographical pain areas and improving by noise adjustment using manual repeated careful removal and inspection. Decision tree 1 is induced from 222 patients. The induced decision tree was trained by the careful removal of weak attributes which had an infrequent incidence in the initial model. Then, the accuracy and decision tree logic were inspected. The removal and inspection process was repeated until the best performing model was achieved. The 1st decision tree, from the 8th run of a 5-folds cross-validation, was altered by removing weak attributes until its accuracy was raised from 85.96% to 87.72%. The attributes removed were discomfort, and number of pain areas, worry, emotional tension, current aggravating factors, diffused/localised, number of life problems, progress of the pain, tender TMJ on examination. This induced decision tree was tested on 57 independent unseen patients previously diagnosed by clinicians. The accuracy of this induced decision tree is equivalent to 88%.

Table 6-8: Frequency table of the diagnosis of 57 patients by the induced decision tree 1 and clinicians.

Clinicians	Induced Decision Tree 1					Total
	AFP	AO	DDWR	FAM	OD	
AFP	7	2	0	1	0	9
AO	1	1	0	0	0	2
DDWR	0	0	4	0	0	4
FAM	1	2	0	35	0	38
OD	0	0	0	0	3	3
Total	9	5	4	36	3	57

Table 6-8 shows the diagnosis of cases assessed by this induced decision tree and the clinicians. The kappa statistic which takes into account the chance agreement is used to measure an agreement of this induced decision tree and the clinicians, and the kappa value is 0.77 with a 95% confidence interval from 0.44 to 1.0 (see Appendix C.6.1) for a full definition of the kappa statistics and calculation for the data in Table 6-8). This corresponds to good agreement with a range from moderate to very good agreement on Altman's suggested interpretative scale (Altman 1991).

- < 0.20 poor agreement
- 0.21 – 0.40 fair agreement
- 0.41 – 0.60 moderate agreement
- 0.61 – 0.80 good agreement
- 0.81 – 1.00 very good agreement

The diagnostic performance represented by sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and positive/negative likelihood ratio are summarised in Table 6-9 and the detail of calculation is described in Appendix C.6.6.

Table 6-9: Discriminative diagnostic performance of the induced decision tree 1.

	AFP	AO	DDWR	FAM	OD
Sensitivity	0.78	0.20	1	0.97	1
Specificity	0.94	0.98	1	0.86	1
Positive predictive value (PPV)	0.70	0.50	1	0.92	1
Negative predictive value (NPV)	0.96	0.93	1	0.95	1
Positive likelihood ratio (LR+)	13	1.67	infinite	6.93	infinite
Negative likelihood ratio (LR-)	0.2	0.8	0	0.03	0

Table 6-9 shows that the sensitivity and specificity of all diagnosis except AO is quite high. Also the likelihood ratio is high. Likelihood ratio for a positive result is the ratio of the chance of a positive result if the patient has the disease to the chance of a positive result if he/she does not have the disease (Petrie & Sabin 2000). For example, a likelihood ratio of 13 for a positive diagnosis of AFP (Table 6-9) indicates that a positive diagnosis for AFP is 13 times as likely to occur in an individual with AFP than one without it. This high likelihood ratio of positive diagnosis of AFP suggests that the decision tree model 1 provides useful information, as does its negative likelihood ratio of 0.2 which is close to

zero. Although the discriminative power of the diagnoses of DDWR and OD is very high, an interpretation needs to be careful because the sample size in both groups is very small. In practical, given the positive test result by the decision tree we want to know that how likely it is that the patient has the disease. This predictive value is depended on prevalence of the disease in the population being studied. If the prevalence of the disease is high the positive predictive value will be much higher than that in the population with lower prevalence.

Of 117 input attributes provided for learning, the induced decision tree model uses 12 attributes, as listed in Table 6-10.

Table 6-10: The classifying parameters for the diagnosis of CFP in the induced decision tree 1

Classifying Parameters
<p>1. main complaints and their values are;</p> <ul style="list-style-type: none"> • pain • clicking or crepitus • limited mouth opening • sticking or locked jaw • TMJ dislocation • disturbance of oral sensation (e.g. burning) • headache • tinnitus • taste change • bite discomfort <p>2. tender_muscle_sum \leq 0 (this parameter uses cut point at 0)</p> <p>3. frequency (constant, intermittant, not applicable)</p> <p>4. analgesia relieving factor (yes, no)</p> <p>5. other complaints 1 and their values are;</p> <ul style="list-style-type: none"> • n/a (not applicable) • pain and salivation and denture intolerance and earache and bruxism and dry mouth and TMJ dislocation • clicking or crepitus • limited mouth opening • sticking or locked jaw • taste change • headache • bite discomfort • disturbance of oral sensation (eg. burning) • nil

Classifying Parameters
6. distribution (unilateral, bilateral)
7. tingling (yes, no)
8. biting/chewing current aggravating factors (yes, no)
9. jaw-moved current aggravating factors (yes, no)
10. sleep relieving factor (yes, no)
11. weather change current aggravating factors (yes, no)
12. hotfood/drink current aggravating factors (yes, no)

Note: Values of parameters are in parenthesis.

All 12 attributes are used for building the induced decision tree (Figure 6-9) for the diagnosis of facial arthromyalgia (FAM), atypical facial pain (AFP), atypical odontalgia (AO), TMJ disc displacement with reduction (DDWR) and oral dysaesthesia (OD). The parameters “main complaint”, “tender muscle =<0”, “frequency”, “analgesia relieving factor”, “other complaint”, “distribution”, and “tingling” are the top three most important parameters as they were placed at the beginning nodes in 1st, 2nd, 3rd level depth of the tree.

```

1MainComplaint pain [Mode: FAM] (176)
  2tender_muscle_sum =< 0 [Mode: AO] (47)
    3OtherComplaint1 clicking or crepitus [Mode: FAM] (9, 0.778) -> FAM
      3OtherComplaint1 limited mouth opening [Mode: FAM] (1, 1.0) -> FAM
      3OtherComplaint1 sticking or locked jaw [Mode: FAM] (1, 1.0) -> FAM
    3OtherComplaint1 taste change [Mode: AO] (1, 1.0) -> AO
    3OtherComplaint1 headache [Mode: AFP] (2, 0.5) -> AFP
    3OtherComplaint1 bite discomfort [Mode: AFP] (3, 0.333) -> AFP
    3OtherComplaint1 disturbance of oral sensation (eg. Burning) [Mode: AFP] (4, 0.5)
      -> AFP
    3OtherComplaint1 nil [Mode: AO] (26)
  4tingling 1 [Mode: AO] (4, 0.75) -> AO
  4tingling 0 [Mode: AFP] (22)
    5sleepRF 1 [Mode: AO] (3, 1.0) -> AO
    5sleepRF 0 [Mode: AFP] (19)
      6weatherchangeCAF 1 [Mode: AFP] (3, 1.0) -> AFP
      6weatherchangeCAF 0 [Mode: AFP] (16)
        7hotfood/drinkCAF 1 [Mode: AO] (3, 1.0) -> AO
        7hotfood/drinkCAF 0 [Mode: AFP] (13, 0.615) -> AFP
  2tender_muscle_sum > 0 [Mode: FAM] (129)
    3tingling 1 [Mode: AFP] (9)
      4bite_chew_CAF 1 [Mode: FAM] (5, 0.8) -> FAM
      4bite_chew_CAF 0 [Mode: AFP] (4, 1.0) -> AFP
    3 tingling 0 [Mode: FAM] (120)
      4jaw_move_CAF 1 [Mode: FAM] (88, 0.955) -> FAM
      4jaw_move_CAF 0 [Mode: FAM] (32)
        5Frequency constant [Mode: AFP] (13, 0.615) -> AFP
        5Frequency intermittent [Mode: FAM] (19, 0.842) -> FAM
        5Frequency not applicable [Mode: FAM] (0.0) -> FAM
1MainComplaint clicking or crepitus [Mode: DDWR] (17)

```

```

2Frequency constant [Mode: DDWR] (0.0) -> DDWR
2Frequency intermittent [Mode: FAM] (1.0)
  3Distribution unilateral [Mode: FAM] (7, 1.0) -> FAM
  3Distribution bilateral [Mode: DDWR] (3, 0.667) -> DDWR
2Frequency not applicable [Mode: DDWR] (7, 1.0) -> DDWR
1MainComplaint limited mouth opening [Mode: FAM] (4, 1.0) -> FAM
1MainComplaint sticking or locked jaw [Mode: DDWR] (4)
  2analgesiaRF 1 [Mode: FAM] (2, 1.0) -> FAM
  2analgesiaRF 0 [Mode: DDWR] (2, 1.0) -> DDWR
1MainComplaint TMJ dislocation [Mode: DDWR] (1, 1.0) -> DDWR
1MainComplaint disturbance of oral sensation (eg. Burning) [Mode: OD] (6, 1.0) -> OD
1MainComplaint headache [Mode: FAM] (1, 1.0) -> FAM
1MainComplaint tinnitus [Mode: DDWR] (2, 0.5) -> DDWR
1MainComplaint taste change [Mode: OD] (3, 1.0) -> OD
1MainComplaint bite discomfort [Mode: FAM] (0.0) -> FAM

```

Figure 6-9: The induced decision tree 1 for the diagnosis of CIFP. The number in front of each line indicates the level depth of the branch of tree. FAM = facial arthromyalgia, AO = atypical odontalgia, AFP = atypical facial pain, DDWR = TMJ disc displacement with reduction, OD = oral dysaesthesia, CAF = current aggravating factors, RF = relieving factors, ASS = associated symptoms and signs, N/A = not applicable. The value 1, 0 after some attributes means yes, no respectively.

At level 1 (see Figure 6-9), the induced decision tree uses “main complaint” as an important parameter for classification, so that this parameter and its values are placed as a root node. This is similar to a clinicians’ diagnostic deduction process for which patients’ complaints are collected at the beginning of history taking. However, in some nodes this decision tree makes diagnoses using only a main complaint. For example, the diagnosis of FAM, DDWR, and OD are made with only one main complaint of “limited mouth opening” or “headache”, “TMJ dislocation” or “tinnitus”, and “disturbance of oral sensation (e.g. burning)” or “taste change” respectively. The confidence and reliability of the leaf nodes of FAM with “limited mouth opening” and of OD with “disturbance of oral sensation” and “taste change” are very high (confidence 1.0). Although it seems to be abrupt to reach a diagnosis in this way, it is acceptable in epidemiological research for employing diagnostic questions to identify orofacial pain conditions. For example, in the surveys of orofacial pain in a population by Macfarlane et al (2002) and Locker & Grushka (1987), a question asking for prolonged burning sensation in the mouth is used to identify OD and a question asking for pain in the jaw joint when open the mouth wide (a cause of limited mouth opening) is used to identify FAM. Headache and tinnitus are recognised as associated symptoms of FAM. The diagnostic value of them has not been studied, and this decision tree does not support their use for diagnosis due to a small number of

cases. The following is the explanation of the diagnostic deduction process of the induced decision tree 1 (see Figure 6-9).

There are 176 patients in the first node with main complaint of pain. Then, a parameter “tender_muscle_sum =<0” which means the number of palpated tender masticatory muscles is used to separate patients into 2 groups, those without tender muscle (contains 47 patients with mode of AO) and those with tender muscle (contains 129 patients with mode of FAM). The sign of muscle tenderness on examination supports the cause from the masticatory muscle (FAM). This confirms our current concept of the diagnosis of FAM. For 47 patients with a main complaint of pain and without tender muscles, the decision tree uses “other complaint 1”³ to further the differential diagnosis, as follows;

- with “other complaint 1” of clicking or crepitus, the diagnosis is FAM. This gives high reliability since it is based on a moderate number of cases (9 cases) and high confidence (0.778). This conforms to TMJ pain without involvement of the masticatory muscles such as in internal derangement of the TMJ.
- with “other complaint 1” of limited mouth opening, the diagnosis is FAM. Although it is based on only one case, but the logic is sound and confirms with our current knowledge.
- with “other complaint 1” sticking or locked jaw, the diagnosis is FAM. It also gives sound logic, though it is based on only one case in this decision tree.
- with “other complaint 1” of taste change, the diagnosis is AO. This based on only one case. Altered taste is a symptom that can coexist with AO and AFP besides OD.
- with “other complaint 1” of headache, the diagnosis is AFP. This based on only two case with just half of the confidence.
- with “other complaint 1” of bite discomfort, the diagnosis is AFP. However, this gives low confidence (0.3). Bite discomfort can be found coexisting with AFP.

³ “Other Complaint 1” is the attribute name used in data mining. The name is not represent the real name of clinical parameter for the diagnosis but for convenient to make a referring in data mining process. There are other attributes for the complaint i.e. main complaint, other complaint 1, other complaint 2, and other complaint 3. It is based on the rationale that a patient may have more than one problem. The possible values of these complaint attributes are “pain”, “clicking/crepitus”, “limited mouth opening” etc.

- with “other complaint 1” of disturbance of oral sensation (e.g. burning), the diagnosis is OD. Some AFP patients present intraoral symptoms such as disturbance of oral sensation coexisting with face pain.

The diagnoses of AFP and AO in this pathway is reasonable however the cases which fall into these leaf nodes are too small to draw a firm conclusion. One obvious reason is that the proportion of AFP and AO in our data set is small.

Of the 26 patients (from 46 patients who have main complaint of pain and without tender muscle) where “other complaint 1” is “nil” which means there is no other complaint apart from the main complaint of pain, the tree uses “subjective tingling”, “relieved by sleep” (“sleepRF”), “aggravated by weather change” (“weatherchangeCAF”), “aggravated by hotfood/drink” (“hotfood/drinkCAF”) as parameters for the classification of AO and AFP. With either “subjective tingling” or “relieved by sleep” or “aggravated by hotfood/drink”, the tree predicts the diagnosis of AO. With “aggravated by weather change”, the tree predicts the diagnosis of AFP. All of these symptoms are recognised as associated symptoms, however they are not used in any published formal classification and are not validated for the diagnosis of orofacial pain. One caution is the use of “aggravated by hotfood/drink” for the diagnosis of AO. Hotfood/drink as a current aggravating factor is well recognised for differentiating pulpal pain, however, we observed that AO can present with this same feature. One common explanation may be the wind up of the central pain pathway. This requires further studies.

For 129 patients who are partitioned into “tender_muscle_sum>0” which means there is tender muscle site on palpation (at least one or more), most of them are diagnosed of FAM. This confirms our current thinking that a pain complaint in association with tender masticatory muscles refers to FAM. The decision tree uses “subjective tingling” and “biting/chewing current aggravating factor” to differentiate FAM from AFP. Therefore, biting/chewing as a current aggravating factor is still a typical predictor of FAM with high confidence (0.8), though patients’ presentation of pain is not typical for FAM because of “subjective tingling sensation”. Of the 120 patients who have not had a tingling sensation, and pain aggravated by “jaw movement” as a current aggravating factor” is used to give a diagnosis of FAM (with a very high confidence 0.955) based on a

large number of cases (88 patients). Once again, it confirms our current thinking of the diagnosis of FAM. For the remaining of 32 patients who have not fulfilled the previous classifying parameters, the decision tree uses frequency of pain (constant, intermittent) to classify further to AFP (using constant pain with confidence 0.6), and to FAM (using intermittent with confidence 0.8). Again, it conforms to our current thinking of typical diagnosis of AFP and FAM.

With 17 patients having main complaint of “clicking or crepitus”, the decision tree uses frequency of pain to differentiate DDWR from FAM. If frequency of pain is “not applicable” which means there is no pain accompanied to main complaint of clicking and crepitus, then the diagnosis is DDWR. If frequency of pain is “intermittent”, then the tree uses unilateral distribution of the complaint to differentiate the diagnosis of FAM from DDWR. The generality of this definition of FAM is questionable; this may not be true for the general population. Biases of data collecting such as referral bias and small sample may be the reasons.

With a small number of 4 patients having main complaint of sticking or locked jaw, analgesic relieving factor is used to differentiate FAM from DDWR. DDWR is defined as disability(ies) of temporomandibular jaw joint without pain, the disability may be present with clicking/crepitus or dislocation of TMJ.

When analysing the discovered knowledge, decision trees and their rules should be used together since both trees and rules are models that lend themselves to be interpreted but for different purposes. Decision trees explicitly demonstrate the process of diagnostic deduction, while decision rules summarise antecedents for the diagnosis. The antecedent of a rule includes a condition for every node on the path from the root to that leaf, and the consequent of the rule is the class assigned by the leaf. Figure 6-10 illustrates rules that were translated from the induced decision tree 1.

Rules for AFP:

Rule #1 for AFP:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == headache
then -> AFP (2, 0.5)
```

Rule #2 for AFP:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
```

```
and OtherComplaint1 == bite
discomfort
then -> AFP (3, 0.333)
```

Rule #3 for AFP:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == disturbance
of oral sensation (eg. Burning)
then -> AFP (4, 0.5)
```

Rule #4 for AFP:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == nil
and tingling == 0
and sleepRF == 0
and weatherchangeCAF == 1
then -> AFP (3, 1.0)
```

Rule #5 for AFP:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == nil
and tingling == 0
and sleepRF == 0
and weatherchangeCAF == 0
and hotfood/drinkCAF == 0
then -> AFP (13, 0.615)
```

Rule #6 for AFP:

```
if MainComplaint == pain
and tender_muscle_sum > 0
and tingling == 1
and bite_chew_CAF == 0
then -> AFP (4, 1.0)
```

Rule #7 for AFP:

```
if MainComplaint == pain
and tender_muscle_sum > 0
and tingling == 0
and jaw_move_CAF == 0
and Frequency == constant
then -> AFP (13, 0.615)
```

Rules for AO:

Rule #1 for AO:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == N/A
then -> AO (0.0)
```

Rule #2 for AO:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == [pain
salivation denture intolerance earache
bruxism dry mouth TMJ dislocation]
then -> AO (0.0)
```

Rule #3 for AO:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == taste change
then -> AO (1, 1.0)
```

Rule #4 for AO:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == nil
and tingling == 1
then -> AO (4, 0.75)
```

Rule #5 for AO:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == nil
and tingling == 0
and sleepRF == 1
then -> AO (3, 1.0)
```

Rule #6 for AO:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == nil
and tingling == 0
and sleepRF == 0
and weatherchangeCAF == 0
and hotfood/drinkCAF == 1
then -> AO (3, 1.0)
```

Rules for DDWR:

Rule #1 for DDWR:

```
if MainComplaint == clicking or
crepitus
and Frequency == constant
then -> DDWR (0.0)
```

Rule #2 for DDWR:

```
if MainComplaint == clicking or
crepitus
and Frequency == intermittent
and Distribution == bilateral
then -> DDWR (3, 0.667)
```

Rule #3 for DDWR:

```
if MainComplaint == clicking or
crepitus
and Frequency == not applicable
then -> DDWR (7, 1.0)
```

Rule #4 for DDWR:

```
if MainComplaint == sticking or locked
jaw
and analgesiaRF == 0
then -> DDWR (2, 1.0)
```

Rule #5 for DDWR:

```
if MainComplaint == TMJ dislocation
then -> DDWR (1, 1.0)
```

Rule #6 for DDWR:

```
if MainComplaint == tinnitus
then -> DDWR (2, 0.5)
```

Rules for FAM:

Rule #1 for FAM:

```
if MainComplaint == pain
and tender_muscle_sum <= 0
and OtherComplaint1 == clicking or
crepitus
then -> FAM (9, 0.778)
```

Rule #2 for FAM:

```
if MainComplaint == pain
```

```

    and tender_muscle_sum <= 0
    and OtherComplaint1 == limited
mouth opening
    then -> FAM (1, 1.0)

Rule #3 for FAM:
    if MainComplaint == pain
    and tender_muscle_sum <= 0
    and OtherComplaint1 == sticking or
locked jaw
    then -> FAM (1, 1.0)

Rule #4 for FAM:
    if MainComplaint == pain
    and tender_muscle_sum > 0
    and tingling == 1
    and bite_chew_CAF == 1
    then -> FAM (5, 0.8)

Rule #5 for FAM:
    if MainComplaint == pain
    and tender_muscle_sum > 0
    and tingling == 0
    and jaw_move_CAF == 1
    then -> FAM (88, 0.955)

Rule #6 for FAM:
    if MainComplaint == pain
    and tender_muscle_sum > 0
    and tingling == 0
    and jaw_move_CAF == 0
    and Frequency == intermittent
    then -> FAM (19, 0.842)

Rule #7 for FAM:
    if MainComplaint == pain
    and tender_muscle_sum > 0
    and tingling == 0
    and jaw_move_CAF == 0
    and Frequency == not applicable
    then -> FAM (0.0)

Rule #8 for FAM:
    if MainComplaint == clicking or
crepitus
    and Frequency == intermittent
    and Distribution == unilateral
    then -> FAM (7, 1.0)

Rule #9 for FAM:
    if MainComplaint == limited mouth
opening
    then -> FAM (4, 1.0)

Rule #10 for FAM:
    if MainComplaint == sticking or locked
jaw
    and analgesiaRF == 1
    then -> FAM (2, 1.0)

Rule #11 for FAM:
    if MainComplaint == headache
    then -> FAM (1, 1.0)

Rule #12 for FAM:
    if MainComplaint == bite discomfort
    then -> FAM (0.0)

Rules for OD:
Rule #1 for OD:
    if MainComplaint == disturbance of
oral sensation (eg. Burning)
    then -> OD (6, 1.0)

Rule #2 for OD:
    if MainComplaint == taste change
    then -> OD (3, 1.0)

Default : -> FAM

```

Figure 6-10: Diagnostic rules translated from the induced decision tree 1. The first number in parenthesis indicates the patients in training data set for whom satisfied with all premises in the rule and the second number indicates the porportion of patients for which the rule is true (confidence). FAM = facial arthromyalgia, AO = atypical odontalgia, AFP = atypical facial pain, DDWR = TMJ disc displacment with reduction, OD = oral dysaesthesia, CAF = current aggravating factors, RF = relieving factors, ASS = associated symptoms and signs, N/A = not applicable, PresentClick 1 = yes for clicking, PresentClick 2 = no for clicking. The value 1, 0 after some attributes means yes, no respectively.

All rules were translated from the induced decision tree and grouped by diagnosis category. The syntax of each rule is of the form

```
IF          condition 1
AND         condition 2
...
...
AND         condition n
THEN       consequence
```

The condition in the syntax of rules is an assessment of a particular parameter on patients. The two numbers in parenthesis after the consequence of rules indicates the number of patients who satisfy the antecedent, and the proportion of patients for which the rule is true (or confidence), respectively. Rules built from training cases are considered to be reliable if they are based on a large number of cases and having high proportion of cases that are true (or confidence). Rules that are based on only one or two cases are subject to overfitting and are unreliable. The overfitting decision tree model has poor accuracy when applied to unseen cases. Therefore, rules which satisfied minimum 3 cases and minimum confidence = 0.6 are considered to be worth investigating.

From Figure 6-10, the rules for the diagnosis of chronic idiopathic facial pain consist of 7 rules for AFP, 6 rules for AO, 6 rules for DDWR, 12 rules for FAM, and 2 rules for OD.

1. Rules for AFP

There are 4 out of 7 rules which pass the criteria of selection. They are rules 4, 5, 6 and 7. It is clearer from rule summary that the diagnostic style of AFP is like a diagnosis by exclusion since its antecedents are based on negative findings. Biting/chewing aggravation is an indicator for FAM. Constant frequency is an indicator for AFP in patients who have tender muscles without jaw-moved aggravation.

2. Rules for AO

There are 3 out of 6 rules that satisfied the selection criteria, i.e. rules 4, 5 and 6.

3. Rules for DDWR

For the diagnosis of DDWR, 2 out of 6 rules satisfied the selection criteria; they are rules 2 and 3. The diagnosis of DDWR depends exclusively on the main complaint of clicking or crepitus in rule 3 and with additional parameters of intermittent frequency and bilateral distribution in rule 2.

4. Rules for FAM

For the diagnosis of FAM, 6 out of 12 rules satisfied the selection criteria; they were rules 1, 4, 5, 6, 8 and 9. Rules 1, 2 and 3 confirm current knowledge of internal derangement. Biting/chewing, jaw-moved aggravating factors, and intermittent frequency of pain are parameters indicating FAM; this knowledge confirms current thinking.

5. Rules for OD

For the diagnosis of OD, both rules used exclusively the main complaint for making a diagnosis. These were disturbance of oral sensation and taste change.

Summary of Model 1

In conclusion, this induced decision tree has good agreement with clinicians ($\kappa = 0.77$), with a 95% confidence interval from 0.44 to 1.0 ranging from moderate to very good agreement. The accuracy is high at 88% and the discriminative performance has suggested useful information to be used in the diagnosis of chronic idiopathic facial pain and in particular for AFP and FAM. Part of the discovered knowledge in this model confirms current knowledge. For example, (1) pain with tender masticatory muscles on palpation and with jaw moved or biting/chewing aggravation is characteristic for the diagnosis of FAM; (2) pain with limited mouth opening, sticking/locked jaw, present clicking without tender muscles are features of FAM with internal derangement; (3) the diagnostic features for DDWR include bilateral clicking/crepitus without pain, or sticking/locked jaw without pain; (4) disturbance of oral sensation and taste change are exclusive features of OD; (5) intermittent frequency of pain is a parameter indicating facial arthromyalgia. However, the other part of discovered knowledge is still in doubt because no such objective confirmation has been proved from previous studies. For example, (1) the induced decision tree

suggests that subjective tingling sensation refers to AO in patients who have pain complaint and without tender muscles; (2) constant frequency is an indicator for atypical facial pain in patients who have tender muscle without jaw-moved aggravation (rule no. 7 for AFP); and (3) hot food/drink aggravation for the differentiation of AO from AFP. The suggested knowledge from the model challenges our current thinking and needs to be proved in a future study.

Model 2

This induced decision tree is an example of decision trees induced by including pain sites and 5% noise adjustment. This tree was trained from 224 under 5% expected noise adjustment and with specific pain sites included. This induced decision tree was tested on independent data set of 56 patients previously diagnosed by the clinicians and the accuracy is 48 out of 56 or equivalent to 85.71%.

Table 6-11: Frequency table of the diagnosis of 56 patients by the induced decision tree 2 and clinicians.

Clinicians	Induced Decision Tree 2					Total
	AFP	AO	DDWR	FAM	OD	
AFP	7	1	0	1	0	9
AO	1	4	0	2	0	7
DDWR	0	0	3	1	0	4
FAM	3	1	0	31	0	35
OD	0	0	0	0	3	3
Total	11	6	3	35	3	56

Table 6-11 shows the agreement assessed by this induced decision tree and the clinicians. The kappa value is 0.81 with a 95% confidence interval from 0.80 to 0.82 (see Appendix C.6.1) for a full definition of the kappa statistics and calculation for the data in Table 6-11). This agreement earns very good agreement in Altman's suggested interpretative scale (Altman 1991).

The diagnostic performance represented by sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) are summarised in Table 6-12.

Table 6-12: Discriminative diagnostic performance of the induced decision tree 2.

	AFP	AO	DDWR	FAM	OD
Sensitivity	0.78	0.80	0.75	0.89	1

	AFP	AO	DDWR	FAM	OD
Specificity	0.91	0.96	1	0.90	1
Positive predictive value (PPV)	0.63	0.67	1	0.94	1
Negative predictive value (NPV)	0.96	0.98	0.98	0.83	1
Positive likelihood ratio (LR+)	0.87	20	infinite	8.9	infinite
Negative likelihood ration (LR-)	0.24	0.21	0.25	0.12	0

Similar to the discussion of Table 6-10, the induced decision tree 2 gives high performance in discrimination of AO and FAM. Although the positive likelihood ratio is very high for DDWR and OD, the interpretation has to be cautious because of the small sample size.

Of 117 input attributes provided for learning, the induced decision tree takes 11 attributes for classifying the diagnosis of chronic idiopathic facial pain, as listed in Table 6-13.

Table 6-13: The classifying parameters for the diagnosis of CIFP in the induced decision tree 2.

Classifying Parameters
<ol style="list-style-type: none"> 1. TMJ (yes, no) 2. supra orbital (yes, no) 3. main complaints and their values are; <ul style="list-style-type: none"> • pain • clicking or crepitus and limited mouth opening and sticking or locked jaw and TMJ dislocation and headache and tinnitus and bite discomfort • disturbance of oral sensation (e.g. burning) • taste change 4. frequency (constant, intermittent, not applicable) 5. dento-alveolar (yes, no) 6. nil current aggravating factors (yes, no) 7. nausea associated symptoms (yes, no) 8. temple (yes, no) 9. numbness associated symptoms (yes, no) 10. fullness in ear associated symptoms (yes, no) 11. clench (yes, no)

Note: Values of parameters are in parenthesis.

All 11 parameters are used to build the induced decision tree 2 (Figure 6-11). The top three most important parameters are pain sites (i.e. TMJ, supra-orbital, dento-alveolar), main complaint, and frequency of pain.

```

1TMJ 1 [Mode: FAM] (170)
  2Supraorbit 1 [Mode: AFP] (6, 0.667) -> AFP
  2Supraorbit 0 [Mode: FAM] (164)
    3Frequency constant [Mode: FAM] (46)
    4nilCAF 1 [Mode: AFP] (4, 0.75) -> AFP
    4nilCAF 0 [Mode: FAM] (42)
      5Temple 1 [Mode: FAM] (15)
      6fullnessinearASS 1 [Mode: FAM] (8, 0.875) -> FAM
      6fullnessinearASS 0 [Mode: AFP] (7)
      7clench 1 [Mode: FAM] (3, 1.0) -> FAM
      7clench 0 [Mode: AFP] (4, 1.0) -> AFP
      5Temple 0 [Mode: FAM] (27, 0.926) -> FAM
    3Frequency intermittent [Mode: FAM] (110, 0.909) -> FAM
    3Frequency not applicable [Mode: DDWR] (8, 1.0) -> DDWR
1TMJ 0 [Mode: AFP] (53)
  2MainComplaint N/A [Mode: AFP] (0.0) -> AFP
  2MainComplaint pain [Mode: AFP] (43)
    3Dento_alveolar 1 [Mode: AO] (25)
    4nauseaASS 1 [Mode: AFP] (4, 0.75) -> AFP
    4nauseaASS 0 [Mode: AO] (21)
      5numbnessASS 1 [Mode: AFP] (5, 0.6) -> AFP
      5numbnessASS 0 [Mode: AO] (16, 1.0) -> AO
    3Dento_alveolar 0 [Mode: AFP] (18, 0.833) -> AFP
  2MainComplaint ['clicking or crepitus' 'limited mouth opening' 'sticking or locked jaw' 'TMJ
dislocation' headache tinnitus 'bite discomfort'] [Mode: AFP] (0.0) -> AFP
  2MainComplaint disturbance of oral sensation (eg. Burning) [Mode: OD] (7, 1.0) -> OD
  2MainComplaint taste change [Mode: OD] (3, 1.0) -> OD

```

Figure 6-11: The induced decision tree 2 for the diagnosis of CIPF. The number in front of each line indicates the level depth of the branch of tree. FAM = facial arthromyalgia, AO = atypical odontalgia, AFP = atypical facial pain, DDWR = TMJ disc displacement with reduction, OD = oral dysaesthesia, CAF = current aggravating factors, ASS = associated symptoms and signs, N/A = not applicable. The value 1, 0 after some attributes means yes, no respectively.

The induced decision tree takes a topographic pain area i.e. TMJ as an important parameter since it is placed at the root node. Of 170 patients (mode FAM) who fall into this TMJ branch, the tree uses supraorbital area to classify AFP with confidence 0.6 based on 6 patients. It is too abrupt to reach a diagnosis of AFP in this way according to the expert's opinion. Of 164 patients who have no pain at supra orbital, the tree uses frequency of pain to classify further, as follows

- with frequency of constant, the tree takes 46 patients with mode of FAM.
- with frequency of intermittent, the tree classifies 110 patients as FAM with high confidence of 0.9. Although, diagnostic features used for

classification is so small, the combination of them (i.e. TMJ and intermittent pain) is specific to FAM.

- with frequency of not applicable, which means pain frequency is not applicable, the tree classifies patients as DDWR with maximum confidence 1.0 based on 8 patients. This fits with our definition of DDWR which has not have pain symptom.

For 46 patients who have constant pain in TMJ, nil current aggravating factor is used to classify AFP with confidence 0.75 based on 4 patients. This is a diagnostic anomaly according to the expert. Of the remaining 42 patients, the tree used a topographical area, temple, to classify 27 patients who have intermittent pain in TMJ not involving temple to FAM. The remaining 15 patients had a differential diagnosis FAM to AFP using “fullness in the ear” and “clenching habit” with confidence of 0.875 and 1.0 based on 8 and 3 patients respectively. The associated symptoms of “fullness in the ear” and “clenching habit” are well recognised in FAM, however studies of predictive value are lacking.

Of 53 patients (mode AFP) with no complaint in the TMJ area, the tree uses a main complaint to classify patients, as follows;

- pain
- disturbance of oral sensation (burning); the tree classifies to OD with the highest confidence 1.0 based on 7 patients.
- change in taste; the tree also classifies to OD with high confidence since all 3 patients reaching this leaf node have OD.

Similarly to the induced decision tree 1, the main complaint is used as a classifier for differential diagnosis. Of 43 patients with a main complaint of pain, the tree uses dento-alveolus area to differentiate patients to mode of AFP using “nausea” and “subjective numbness” associated symptom. This is a challenging hypothesis since the two associated symptom are reported in AFP patients. It will be necessary to study this further to prove or disprove this hypothesis. Like the induced decision tree 1, the diagnosis of OD uses only one main complaint of disturbance of oral sensation or taste change.

The induced decision tree 2 can be translated into rules as the following Figure 6-12.

Rules for AFP:

Rule #1 for AFP:

if TMJ == 1
and Supraorbit == 1
then -> AFP (6, 0.667)

Rule #2 for AFP:

if TMJ == 1
and Supraorbit == 0
and Frequency == constant
and nilCAF == 1
then -> AFP (4, 0.75)

Rule #3 for AFP:

if TMJ == 1
and Supraorbit == 0
and Frequency == constant
and nilCAF == 0
and Temple == 1
and fullnessinearASS == 0
and clench == 0
then -> AFP (4, 1.0)

Rule #4 for AFP:

if TMJ == 0
and MainComplaint == N/A
then -> AFP (0.0)

Rule #5 for AFP:

if TMJ == 0
and MainComplaint == pain
and Dento_alveolar == 1
and nauseaASS == 1
then -> AFP (4, 0.75)

Rule #6 for AFP:

if TMJ == 0
and MainComplaint == pain
and Dento_alveolar == 1
and nauseaASS == 0
and numbnessASS == 1
then -> AFP (5, 0.6)

Rule #7 for AFP:

if TMJ == 0
and MainComplaint == pain
and Dento_alveolar == 0
then -> AFP (18, 0.833)

Rule #8 for AFP:

if TMJ == 0

and MainComplaint == [clicking or
crepitus limited mouth opening sticking or
locked jaw TMJ dislocation headache
tinnitus bite discomfort]
then -> AFP (0.0)

Rules for AO:

Rule #1 for AO:

if TMJ == 0
and MainComplaint == pain
and Dento_alveolar == 1
and nauseaASS == 0
and numbnessASS == 0
then -> AO (16, 1.0)

Rules for DDWR:

Rule #1 for DDWR:

if TMJ == 1
and Supraorbit == 0
and Frequency == not applicable
then -> DDWR (8, 1.0)

Rules for FAM:

Rule #1 for FAM:

if TMJ == 1
and Supraorbit == 0
and Frequency == constant
and nilCAF == 0
and Temple == 1
and fullnessinearASS == 1
then -> FAM (8, 0.875)

Rule #2 for FAM:

if TMJ == 1
and Supraorbit == 0
and Frequency == constant
and nilCAF == 0
and Temple == 1
and fullnessinearASS == 0
and clench == 1
then -> FAM (3, 1.0)

Rule #3 for FAM:

if TMJ == 1
and Supraorbit == 0
and Frequency == constant
and nilCAF == 0
and Temple == 0
then -> FAM (27, 0.926)

Rule #4 for FAM:

if TMJ == 1
and Supraorbit == 0

<p>and Frequency == intermittent then -> FAM (110, 0.909)</p> <p>Rules for OD: Rule #1 for OD: if TMJ == 0 and MainComplaint == disturbance of oral sensation (eg. Burning)</p>	<p>then -> OD (7, 1.0)</p> <p>Rule #2 for OD: if TMJ == 0 and MainComplaint == taste change then -> OD (3, 1.0)</p> <p>Default : -> FAM</p>
---	---

Figure 6-12: Diagnostic rules translated from the induced decision tree 2. The first number in parenthesis indicates the patients in training data set for whom satisfied with all premises in the rule and the second number indicates the porportion of patients for which the rule is true (confidence). FAM = facial arthromyalgia, AO = atypical odontalgia, AFP = atypical facial pain, DDWR = TMJ disc displacment with reduction, OD = oral dysaesthesia, CAF = current aggravating factors, ASS = associated symptoms and signs, N/A = not applicable. The value 1, 0 after some attributes means yes, no respectively.

There are 8 rules for AFP, 1 rule for AO, 1 rule for DDWR, 4 rules for FAM, and 2 rules for OD were translated from the decision tree 2. The criteria for selecting reliable rules is similar to previous models i.e. a minimum 3 cases and a minimum confidence of 0.6. The following is the rule analysis for induced decision tree 2.

1. Rules for AFP

Rules 1, 2, 3, 5, 6 and 7 satisfy the selection criteria. Rule 2 takes TMJ, constant frequency, with nil current aggravation. This rule does not explicitly mention what the main complaint is, however the constant frequency, implicitly refers to the pain complaint of pain. Rule 7 takes main complaint of pain, not in TMJ, and not in dento-alveolus for the diagnosis of AFP. The reasoning for diagnosis of this rule is too abrupt.

2. Rules for AO

There is only one rule which takes pain in dento-alveolus without nausea and subjective numbness associated symptoms for the diagnosis of AO. The rule challenges for a new hypothesis.

3. Rules for DDWR

There is only one rule which takes TMJ without pain in the diagnosis of DDWR. Once again it is too abrupt to reach a diagnosis of DDWR, though it partly supports the definition of DDWR as defined by clicking without pain when opening/closing.

4. Rules for FAM

There are 4 rules for the diagnosis of FAM of which all rules are satisfied with the selection criteria. All rules do not explicitly mention what main complaint are.

5. Rules for OD

There two rules for OD. These two rules takes only main complaint of disturbance of oral sensation and taste change for the diagnosis of OD.

Summary of Model 2

In conclusion, the agreement of the induced decision tree 2 to clinicians is very good ($\kappa = 0.81$), with a 95% confidence interval from 0.80 to 0.82. The accuracy of this model is 85.71% with the high discriminative performance in particular for AO and FAM. TMJ area is the most important attribute as the model places it at root node. “Nil current aggravating factor” is used to differentiate AFP. Moreover, the current thinking about FAM is confirmed as “fullness in the ear associated symptom” and “clenching” are used as classifiers for FAM but the study of predictive value is lacking. It also suggested a challenging idea that “nausea associated symptom” and “subjective numbness associated symptom” has some role in AFP and AO. The diagnosis of OD is similar to the induced decision tree 1 that both use a main complaint of disturbance of oral sensation or change of taste for the diagnosis of OD. This induced decision tree does not explicitly take the main complaint for the diagnosis. This may be unfamiliar to clinicians who usually deduce a diagnosis using the main complaints as important elements.

6.4. Discussion and Conclusions

This study has considered how machine learning techniques, in particular decision tree learning, knowledge discovery in databases, and data mining can contribute to the diagnosis of chronic idiopathic facial pain. The induced decision trees and rules were generated from the learning algorithm, C5.0 using patients previously diagnosed by clinicians. The induced symbolic pattern captures aspects of the clinicians’ classification scheme. The accuracy performance of the model is measured by testing it on unseen cases using the clinician’s diagnosis as a gold standard. In this study, the induced decision trees models produced moderate to good agreement with the clinicians. The accuracy rate is high with high discriminative performance. However, the

accuracy of the model suffers bias because the test data set were collected from the same clinical setting to the training data set. Moreover, the data in this study were obtained from the patients presenting to a Facial Pain Clinic. This introduces a form of “referral bias” since our derivation data set contains only patients who have been screened from the primary care setting. These patients are mostly chronic idiopathic facial pain rather than dental pains which is more common elsewhere. It remains to be seen whether the models will perform well in these other situations where the prevalence of chronic idiopathic facial pain is presumably low. The accuracy of a induced decision tree can be improved by correction of overfitting and accuracy for noise (or error) in the data. From this study, we adjusted the noise to 5% and the degree of pruning to 82%.

These induced decision trees are parsimonious since they use a small number of attributes, between 8 to 15 attributes from a total of 117 attributes. In all the induced decision trees generated, there are attributes which act as good classifiers for the diagnosis. These good classifiers are those that occur high in the induced decision tree (i.e. near the root of the tree) or those which frequently appear in the tree. In general, induced decision trees can be viewed as suggesting a series of hypotheses which may explain the diagnosis of chronic idiopathic facial pain in various situations. Therefore, the induced decision tree generated should be inspected by an expert in their area to confirm, or discard, or refine these hypotheses. In this study, the attributes that were selected by the induced decision tree models were similar to those used by clinicians as important predictors in diagnosis. For example, the main complaint of pain, aggravation by jaw-movement or biting/chewing, and tender masticatory muscle on palpation are used for the diagnosis of facial arthromyalgia. However, some suggested hypotheses can be viewed as challenging. For example, nausea associated symptom, subjective numbness associated symptom are classifiers for atypical facial pain. These suggested hypotheses need further objective investigation. In order to increase robustness of the models, more data should also be included in any analysis.

In conclusion, machine learning techniques are a useful approach for analysing orofacial pain data. The outcome is a readable decision tree and should be verified by a domain expert before use. The induced knowledge should be further validated in other environments such as in a primary care setting to test

its robustness. Moreover, the models can be validated with other diagnoses with can cause common orofacial pain, in particular dental pain. Furthermore, the explicit symbolic decision pattern of the model is useful for developing a learning aid and a guideline for practitioners.

CHAPTER 7

VALIDATION OF THE EXPERT KNOWLEDGE MODEL

7.1. Introduction

Evaluation is a crucial element in the development of any clinical decision support systems. It has been recognised that development and evaluation should be iterative with continuous cycles of both taking place. The evaluation should commence at the very beginning of a project when changes are, relatively speaking, easy and inexpensive to make. The components of a decision support system that should be evaluated are the human-computer interface, database scheme, medical terminology, knowledge base, and inference engine (a managing part that can handle how the knowledge base can make inference from patient data with effectiveness and efficiency).

The term evaluation means a measure of the worth of the system with the intention to determine its relevance, progress, efficiency, effectiveness and potential impact (Nykanen, Chowdhury, & Wigertz 1991). Validation is a measure of how well the knowledge base conforms to the knowledge domain that has been modelled. Validation is part of the evaluation process that focuses on the correctness of the output of the knowledge base. In contrast, verification is a demonstration of consistency, completeness and correctness of the software. Verification aims to eliminate errors in the software and to certify that it has been built according to the specification. Validation and Verification are often used interchangeably.

Evaluation can be considered in 3 phases (Wyatt & Spiegelhalter 1990a):

- Phase 1: An iterative build-test-refine cycle to fulfil the definition phase.
- Phase 2: The laboratory test phase by the users and the experts who can approve the system. The purposes of testing are to measure

whether the knowledge source and accuracy are appropriate, and to measure other subjective aspects such as user satisfaction.

- Phase 3: The field trial or clinical trial phase which is the examination of the effects of the system on the structure, process and outcome of health care in the clinical setting.

Most of the published studies have examined the performance of diagnostic decision support systems in the laboratory test phase, but few studies have tested the system performance and impact on health care systems in a clinical field trial (Mitchell & Sullivan 2001), (Hunt, Haynes, Hanna, & Smith 1998). It is sensible to investigate further those systems with a good performance in the laboratory test phase before field trial studies, which are expensive. Many of the studies of system accuracy have been validated in circumstances which introduce bias. Particularly as systems are usually assessed from cases taken from a single clinical setting and the system developers provide the test data and interpret the results of performance.

The hand-crafted decision trees resulting from Chapter 5 are considered to be the knowledge base of the Clinical Decision Support System for the diagnosis of CIFP. Therefore, the term “hand-crafted decision trees” and “knowledge base” is used interchangeably in this chapter. We focus on the validation of these hand-crafted decision trees in the laboratory test phase. The objective of this chapter is; (1) to test the accuracy of these hand-crafted decision trees for the diagnosis of CIFP compared to diagnosis recorded by clinicians (2) to find errors, inconsistency, and incompleteness in the decision tree pathway (or knowledge representation) of this knowledge model.

7.2. Materials and Methods

7.2.1. Clinical Cases

The test cases comprised 308 previously diagnosed cases of orofacial pain taken from the EEPP. The patients attended the Facial Pain Clinic in the department of Oral and Maxillofacial Surgery at the Eastman Dental Hospital, a triage clinic in a tertiary health care hospital, between July and October 1998 and between February 1999 and March 2002. The eligible patients were aged between 18 and 80, having the ability to communicate using English. The

objective questionnaire, the FPP, was employed for the patient history taking and clinical examination. A diagnosis of orofacial pain was completed by 3 experienced clinicians and 1 expert.

7.2.2. Gold standard

The gold standard for testing the accuracy of the hand-crafted decision trees of the Clinical Decision Support System is the diagnosis of 308 real clinical cases by clinicians (as mentioned in 7.2.1).

7.2.3. Programming and Software

The diagnostic rules were translated from the 6 topographic pain areas of the hand-crafted decision trees. These comprised 16 rules of the frontal decision tree, 21 rules of the TMJ and parietotemporal decision tree, 84 rules of the maxilla decision tree, 78 rules of the mandible decision tree, 67 rules of the teeth and alveolus decision tree, and 11 rules of the oral mucosa decision tree. These translated diagnostic rules are provided in Appendix B. All rules were converted into Clementine language syntax, for which each rule was represented by one field derived node of the Clementine software. The diagnostic rules in Clementine language syntax are documented in Appendix D.

7.2.4. Outcome Measure

Performance of these hand-crafted decision trees is measured directly by the accuracy of the diagnosis compared to those of the clinicians. An indirect effect on the performance is any incompleteness of a decision tree pathway in this knowledge model. In addition, rules which are never used may slow down the system. The outcomes of these measures are described in the following subsections.

7.2.4.1. Accuracy of the Knowledge base of the Decision Support System

Each hand-crafted decision represents for one area of pain which leads further to other clinical data and finally to the diagnoses. A patient may have pain in more than one topographical area, therefore more than one decision tree can be triggered. The outcome of diagnosis is possibly a list of several diagnoses.

The degree of correctness of the diagnosis is graded into 5 categories as follows:

1. All diagnoses are correct. It is signified as “correct” (C).
2. At least one diagnosis is correct and the majority of the wrong diagnoses are close to being correct, termed “an incorrect homologous diagnosis”. This is signified as “partially correct with an incorrect homologous diagnosis” (PC/HO). The possible maximum are 6 diagnoses from 6 decision trees, and the criteria for any diagnosis which is incorrect homologous are;
 - a) a diagnosis in the same anatomical area, for example facial arthromyalgia, where osteoarthritis, osteoarthrosis, and disc displacement with reduction, are close to being correct.
 - b) a diagnosis of the same pain characteristics which involving in a wider area, for example atypical facial pain may be involved intraorally as a diagnosis of atypical odontalgia, or sometimes as oral dysaesthesia.
3. At least one diagnosis is correct and the majority of the wrong diagnoses are heterologous. This is signified as “partially correct with an incorrect heterologous diagnosis” (PC/HET). The possible maximum are 6 diagnoses, and the criteria for any diagnosis which is incorrect heterologous are;
 - a) a diagnosis of a different cause of pain, for example, dental pain, and pain from lesions in the bone or sinus or idiopathic pain.
 - b) a diagnosis from a different anatomical area source, for example, pain from the sinus, or teeth, or brain.
4. All diagnoses are wrong. It is signified as “wrong” (W).
5. The knowledge base can not give any diagnosis or “non diagnosis” (ND).

7.2.4.2. Verification of the Programming Code

It is possible that in transferring the hand-crafted decision trees from paper to “Clementine” language syntax, rules errors could have been introduced. Therefore, it is important to detect such errors of translation.

Thirty one cases (10% of 308 cases) were randomly taken from the 308 cases. The clinical data of these cases were manually inspected using the paper-based hand-crafted decision trees of the knowledge base to accomplish the

diagnoses. The diagnoses then were compared with those generated from the Clementine programming code to verify the correctness of rule transferring.

7.2.4.3. Completeness and Consistency in the Knowledge Base of the Decision Support System

The behaviour of the knowledge representation of the knowledge base (hand-crafted decision trees) of the Decision Support System was examined to identify errors, completeness, consistency of the decision tree pathway, and translated rules which never fire.

7.2.5. Statistics Methods

The accuracy of the diagnosis, was expressed as the overall correctness of the knowledge base of the Decision Support System.

7.3. Results

7.3.1. Characteristics of Test Cases

The frequency of diagnoses in the 308 cases is shown in Table 7-1.

Table 7-1: The frequency of the diagnoses in the group of 308 patients.

Diagnosis	Frequency of the diagnosis
Facial arthromyalgia (FAM)	173
Atypical facial pain (AFP)	45
Atypical odontalgia (AO)	28
Oral dysaesthesia (OD)	16
TMJ disc displacement with reduction (DDWR)	18
Osteoarthritis of TMJ (OA)	9
Trigeminal neuralgia (TN)	3
Hybrid of AFP/TN	4
Pulpitis	5
Periapical abscess	2
Periodontitis	2
Facial migrainous neuralgia (FMN)	1
Migraine	2
Tension headache	1
Anaemia	1

7.3.2. Converting Rules into the Clementine Syntax

Rules translated from hand-crafted decision trees in the knowledge base were rewritten into the Clementine syntax via the visual programming interface of a field derived node (Figure 7-1).

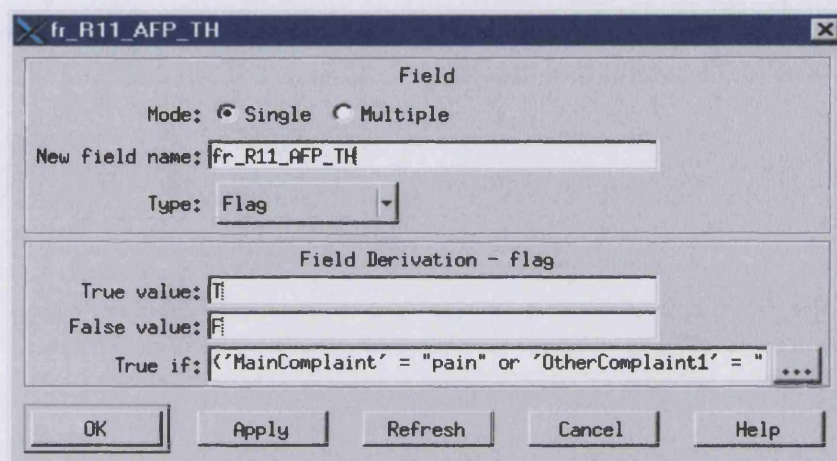


Fig. (a): The new field "fr_R11_AFP_TH" is created for receiving the true/false result of the evaluation of rule 11.

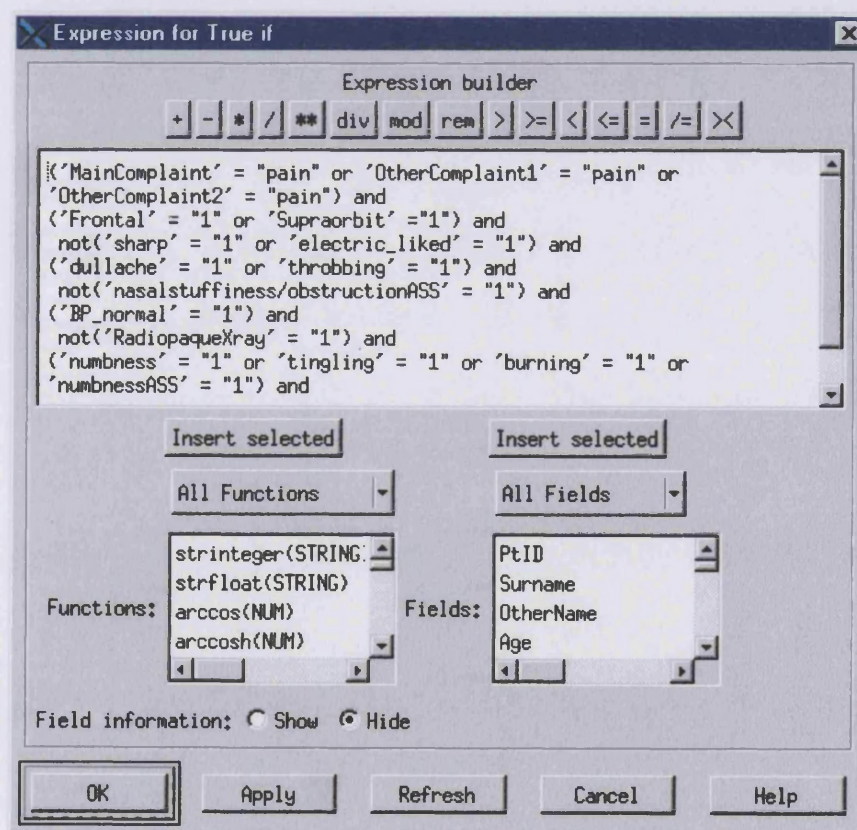


Fig. (b): The Clementine syntax of rule 11 is shown in the linked interface and used to assess the true value of the field "fr_R11_AFP_TH"

Figure 7-1 (Fig. (a) and (b)): The diagnostic rule 11 for "atypical facial pain (AFP) or tension headache (TH)" from the frontal decision tree was converted to the Clementine environment. The programming code for the diagnostic rule 11 is shown in the visual interface in Fig. (b).

The example from Figure 7-1 is the conversion of rule 11 in the hand-crafted decision tree of frontal region in the knowledge base of the Decision Support System. Rule 11 is

IF	complaint is pain AND site is frontal region AND NOT quality of pain is short sharp/stabbing OR electric like AND quality of pain is dull ache to severe throbbing AND NOT nasal obstruction AND normal Blood Pressure AND NOT OM. X-ray opaque frontal or sphenoid sinus AND numbness OR tingling OR burning AND normal MRI
THEN	possible diagnosis is atypical facial pain OR tension headache.

Figure 7-2: The content of diagnostic rule 11 for “atypical facial pain or tension headache”.

when converted into Clementine language syntax, this rule is written as

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1") and
not('sharp' = "1" or 'electric_liked' = "1" )and
('dullache' = "1" or 'throbbing' = "1") and
not('nasalstuffiness/obstructionASS' = "1") and
('BP_normal' = "1") and
not('RadiopaqueXray' = "1") and
('numbness' = "1" or 'tingling' = "1" or 'burning' = "1" or
'numbnessASS' = "1") and
('norm_CN_finding' = "1")
```

Figure 7-3: The Clementine language syntax for the diagnostic rule 11.

This rule evaluates the patient data in the database by checking whether they meet the antecedents (criteria set out in the successive series of Figure 7-2 above). If they do then this patient has the diagnosis atypical facial pain or tension headache. Similarly, other rules were converted into such fields by Clementine and evaluated against the patient data.

7.3.3. Accuracy of the Knowledge Base of the Decision Support System

Since the knowledge base of the Decision Support System uses pain areas as a trigger to operate a decision tree, each patient has the possibility of having more than one suggested diagnosis. The 5 grade criteria of diagnostic

correctness were applied to the diagnostic outcome in order to identify the degree of correctness as shown in Table 7-2.

Table 7-2: Degree of diagnostic correctness in the diagnostic outcome of 308 cases.

Degree of correctness	Distribution of outcomes
All correct (C)	226
Partially correct with an incorrect homologous diagnosis* (PC/HO)	7
Partially correct with an incorrect heterologous diagnosis** (PC/HET)	14
All wrong (W)	47
Nil diagnosis (ND)	14

* an incorrect homologous diagnosis means – an incorrect diagnosis is in the same area or manifesting the same clinical features as that of the correct diagnosis. ** an incorrect heterologous diagnosis means – different cause or different area

The accuracy is calculated from the cases which were in the top three of the degree of correctness i.e. all correct, partially correct with an incorrect homologous diagnosis, and partially correct with an incorrect heterologous diagnosis. Of the nil diagnosis group, it was found that 3 patients have complaints of headache only, 1 patient has pain in the occipital area only, and 2 patients have taste change alone. These 6 patients were out of the context of what the knowledge base of the Decision Support System expected to deal with. Moreover, it was found in the wrong group that 9 patients who have osteoarthritis based on the criteria of pain in the TMJ with signs of joint destruction were wrongly diagnosed as facial arthromyalgia by clinicians. Therefore, these 9 cases will be included in the correct group. The proportion of diagnostic accuracy is 256 out of 302 or 84.8%.

7.3.4. Verification of the Clementine Programming Code

The programming code in Clementine syntax was verified by comparing the manual decision tree of the knowledge base diagnosis of a random sample of 31 cases (10% of the 308 cases) with the computerised diagnoses. The results showed that the programming codes of every case were all correct.

7.3.5. The Behaviour of the Decision Tree Pathway in the Knowledge Base of the Decision Support System

The rules of 6 topographic area hand-crafted decision trees were investigated to see how they resulted in the diagnosis. The summary of this data is shown in Table 7-3.

Table 7-3: The outcome of the rules of 6 topographic area decision trees in the knowledge base of the Decision Support System for the diagnosis of CIPF.

Topographic area decision tree	Total rules in the decision tree	No. of rules used for the diagnosis	No. of times the rules were utilised
Frontal	16	8	28
Maxilla	84	17	73
Mandible	78	16	113
TMJ	21	11	223
Teeth & alveolar	68	12	55
Mucosa	13	4	28

Table 7-3 shows that not all the rules in the decision trees are used for the diagnosis and some rules are more frequently utilised than others. One reason why some rules were not utilised is that our decision trees have been designed to cover all possible diagnoses, but the distribution of our data set was very specialised excluding dental pain, trigeminal neuralgia, and many pathological lesions. It also shows that some rules (or pathways) were commonly employed for the diagnosis because of common features in the patients. For example, the common feature for facial arthromyalgia is dull pain provoked by opening/yawning/biting/chewing and tender TMJ/masticatory muscles whereas sharp pain is unusual.

Once the hand-crafted decision tree is triggered by the topographic pain area, then the next node is assessed as true or false against patient data, and so the process flows via the "true" value branch of this node to the next node and so the process is repeated until reaching the diagnosis (terminal node). This logical controlled process is called forward chaining and it can also be referred to as data driven since the process involves a movement from data to goals (diagnosis). Our hand-crafted decision tree process is a simple forward chaining

which is not as complicated as the inference engine of classical Decision Support Systems. Each time when a tree is triggered it produces one conclusion (diagnosis). In other words only one pathway (or one rule) of the decision tree is used at each time of activation. However, errors can occur causing rules not to be activated. The errors can be incompleteness of the pathway or inconsistency of the process in the decision tree. The following Table 7-4 is the summary of expert rules' behaviour.

Table 7-4: The expert rules' behaviour.

Topographic area decision tree	Expected activated rules	Actual activated rules	% of rules activated
Frontal	33	28	85%
TMJ	124	113	91%
Maxilla	235	223	95%
Mandible	90	73	81%
Teeth & alveolus	71	55	78%
Mucosa	39	28	72%

Table 7-4 shows that some rules do not successfully lead to the diagnosis. The errors and faulty behaviour are summarised as follows;

- the hand-crafted decision trees do not cover all clinical parameters.

Examples are, (i) dull/throbbing pain is not acknowledged in the oral mucosa decision tree, (ii) discomfort or an electric-liked pain are not defined in the teeth and alveolus decision tree and in the TMJ decision tree, (iii) chewing and or talking is not defined as an aggravating factor for trigeminal neuralgia in maxilla, mandible, and mucosa decision trees, (iv) headache, altered taste and limited mouth opening are not designated as complaints in these decision trees.

- the hierarchy of a clinical parameter in the hand-crafted decision tree will influence the diagnosis.

For example, sharp pain is placed before dull pain, therefore patients with both types of pain will be assessed on the sharp pain pathway only. Another example is the order of biting/chewing and opening/yawning in the decision trees of the maxilla, and mandible.

- an error in recording the diagnosis anterior disc displacement and facial arthromyalgia in our data.

The diagnosis of anterior disc displacement with reduction implies the absence of pain – i.e. sticking and clicking only. However, this may also be part of a facial arthromyalgia presentation. This may cause an error in recording the diagnosis in our data.

- there is no representative pathway for some diagnoses in the hand-crafted decision trees.

An example is a spontaneous sharp pain not provoked by jaw functioning or facial movement or facial touch which is not defined in the TMJ (including parietotemporal area) decision tree. This can lead to no diagnosis.

- the hand-crafted decision trees cannot give a diagnosis in patients who have lost their pain.

Hence it has to be used retrospectively.

- the hand-crafted decision tree may not judge the relative importance of certain signs and symptoms.

For example, pain in the upper teeth with the chance finding of a polyp in maxillary sinus can confuse the hand-crafted decision tree and lead to a diagnosis of maxillary carcinoma instead of atypical odontalgia, with an incidental finding. Therefore, the radiographic finding should be site specific recorded in the database.

- the hand-crafted decision tree may be activated by pains in different areas.

This can occur in a patient who had a sharp pain provoked by opening in the TMJ and a dull pain in mandible. In this case, there is a need to specify the pain quality to the appropriate area. The pain quality must be site specific for a meaningful diagnosis.

- nasal obstruction and stuffiness were found to be non-specific to facial migrainous neuralgia in this data set.

There can also be associated symptoms of the atypical facial pain patient. Therefore, this pathway in the hand-crafted decision tree should be refined for the differential diagnosis of atypical facial pain and facial migrainous neuralgia unless one considers the possibility of a hybrid atypical facial pain and facial migrainous neuralgia.

- the diagnoses of the hand-crafted decision tree can be naive.

For example, with a clinical diagnosis of hybrid atypical facial pain and trigeminal neuralgia the decision tree proposes atypical facial pain at one site and trigeminal neuralgia. This raises the question as to whether the patient truly has a hybrid condition or two separate coexisting pain conditions. Only the clinician can decide to designate the case as hybrid or independent coexisting pains. It can be seen that the intuitive assumptions of the expert may be challenged by the logical processing of the decision tree.

- the hand-crafted decision tree is disinterested.

For example, in an osteoarthritis patient (as recorded in the Proforma), the decision tree gave the correct diagnosis and an additional diagnosis of chronic periodontitis which may not have been recorded because the clinician assumed that it was not the cause of the patient's pain complaint.

7.4. Discussion

Perfect gold standards for diagnosis do not exist in medicine (Shortliffe 1987), (Friedman & Wyatt 1997a). However, the extent to which these standards are less than perfect can be estimated and expressed as forms of error. We used the human clinician's diagnosis as our gold standard to test the performance of the knowledge base of the Decision Support System for the diagnosis of CFP. Validation is intended to estimate the consensus agreement between clinicians and the system. However, the agreement between the clinician's opinion and the system is never an absolute nor an adequate criterion, it is just one parameter which gives some idea of performance of the system. When clinicians and the system agree, it may merely be a coincidence of errors of judgement. When the system disagrees with clinicians, it may be that the clinicians are in error. As stated the results are produced as a list of diagnostic outcomes from each activated topographic area of the hand-crafted decision tree. The diagnostic outcomes can be homogeneous pointing to one diagnosis, however in some cases the outcome may give several different diagnoses for that patient so that a true consensus diagnosis cannot be achieved. For example, a patient may have been diagnosed with facial arthromyalgia by a clinician, and the knowledge base of the Decision Support System suggests 2 diagnoses i.e. facial arthromyalgia and atypical facial pain. In this case it is

questionable as to which diagnosis can be used. Therefore, it was not possible to apply kappa statistics, normally used to measure the agreement of two diagnostic methods for the presence of a particular disease. Hence, the accuracy of the diagnostic knowledge is important in this study. The accuracy of the knowledge base of the Decision Support System diagnosis compared to the clinicians diagnosis was 84.8%. This may be considered to be a partially correct overall diagnosis for the patient. In the series used to validate the system, 235 patients were completely correct and 7 patients partially correct with an incorrect homologous diagnosis. Fourteen were partially correct with an incorrect heterologous diagnosis (see section 7.2.4.1 for explanation of these categories).

Bias can be introduced in any validation study. It should be noted that in the first stage of validation by testing the accuracy of the knowledge base, the system developer (P.C.) has become an evaluator. Rigorous validation is needed from an outside agent. It has also been shown that there is sampling bias because our data demonstrated an inadequate representation of some cases. For instance, our data lacks dental pain, trigeminal neuralgia, maxillary sinusitis, neoplastic, and mucosal lesions. These cases are common in other appropriate specialist clinics. To reduce the sampling bias and achieve robustness, the knowledge base of the Decision Support System needs further validation using these other types of facial pain cases. However as can be seen this is beyond the scope of this thesis and would be the basis of a thesis itself.

It is generally accepted that human reasoning and decision-making can show imperfections such as being distorted by personal rational or emotional bias, and such errors are prominent when there is uncertainty in the clinical information. Moreover, the clinicians capability can be limited by overwhelming information as observed in the study of McDonald (1976). This study has shown that the knowledge base of the Decision Support System arranged in a simple logical decision tree can contribute to the diagnosis in an objective way and can even correct the diagnosis of a clinician. However, the philosophical aspect of human reasoning and decision-making are still debated. One school of thought argues that decision-making is rational in that it contains practical tradeoffs of opposite elements, while another says that rational decision-making has to

comply with quantitative mathematical method based on probabilities (Fox, Glasspool, & Bury 2001).

We used a simple approach to test the knowledge for the diagnosis of CIFP. The Clementine system was chosen as a means for testing the diagnostic rules constructed for the decision tree from the knowledge base. There were some advantages to Clementine testing: (1) it is easy to work with since communication with Clementine is via a visual interface; (2) there is no need for extensive programming skills. However, Clementine lacks the strength of high-level programming that is used in many decision support systems.

Our decision tree is binary with a yes/no structure which means that there are only two possible descending branches leading to the next node. This arrangement has shown a weakness which can cause partial evaluation of contradicting clinical data. The more dominant data which is in a higher order of the tree will be assessed and leave the less dominant data of the same category not assessed. The solution is to place the conflicting categories of the parameter in the same level of the decision tree so that the decision tree can detect all possible data at that level for further assessment. Taking quality as an example, dull and sharp pain will be placed at the same level in the new decision tree (see Figure 7-4)

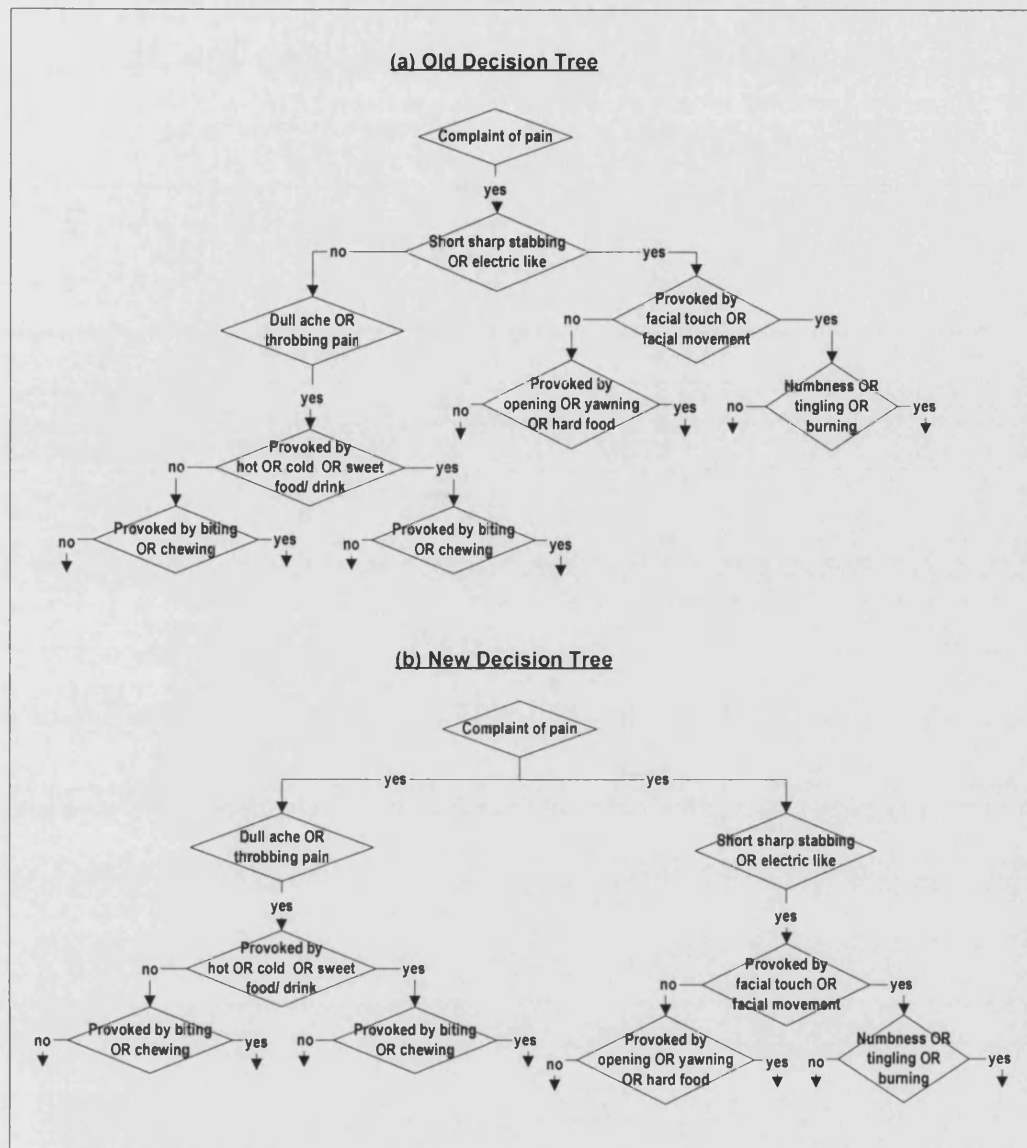


Figure 7-4: Comparison of the old tree and the new tree for which the quality of pain is placed in the same level.

Only further analysis will reveal similar hierarchical problems in the decision tree arising from mixed contradictory qualities.

7.5. Conclusion

The study has demonstrated that the knowledge base of the Decision Support System for the diagnosis of CFP can capture the content of the expert domain (i.e. his/her pain knowledge) and represent it in a way that is understandable and will lead to the diagnosis of orofacial pain. The accuracy of the diagnosis is quite good at 84.8% and shows a promising capability. The Clementine

software has been shown to be an alternative means for testing the rules translated from the hand-crafted decision trees in the knowledge base.

This study has also revealed the shortcomings of the knowledge base for the diagnosis of CIFP which can be improved for system development in the future. It is obvious that there is also a need to include a wide variety of cases in particular dental pain to test the rules. Further software development is required to integrate the hand-crafted decision tree knowledge base with the patients database repository and to quantify the uncertainty of the diagnosis.

CHAPTER 8

SUMMARY AND CONCLUSIONS

8.1. Summary and Conclusions

This thesis explored the potential for developing a computerised decision support system for chronic idiopathic facial pain diagnosis. The research was motivated by the following: (1) the difficulty for some clinicians to diagnose chronic idiopathic facial pain, and (2) the many opportunities arising from deploying computing technology in the field of orofacial pain. Diagnostic difficulty can come from 3 causes: (1) there is a lack of identifiable laboratory and imaging data to support the diagnosis which means the diagnosis relies on the pain history which is invariably rich with information; (2) the needs for a multidimensional approach requires a history taken from different perspectives which takes a considerable time for the untrained; and finally (3) the complexity of orofacial pain clinical features overlap with different pain conditions.

Hence, we have developed a well structured electronic medical record which could also be used as a clinical data collecting module supporting a decision support system. In addition, we constructed a logical decision tree for the diagnosis of chronic idiopathic facial pain to be used as a guideline in clinical practice and for training inexperienced clinicians.

As was mentioned in Chapter 1, the traditional biomedical model which influences most medical training shows a lack of ability to explain all aspects of pain. This model has the assumption that disease is generated by specific aetiological causes which leads to changes in the body structure and function. It also sees mind (psyche) and body (soma) as working independently. In this biomedical model, all causes are categorised as somatic or psychological and when the somatic cannot be found, a psychological aetiology is claimed, which

translates in the patient's mind as an imagined problem. This situation is particularly true of chronic pain including chronic idiopathic facial pain. The more appropriate model is the biopsychosocial model which suggests that the person is a complex unit of body and mind that one cannot separate. It accepts that biological, psychological, behavioural and social factors are all present and it is their interaction that affects the individual and the disorder. Thus, the biopsychological model contributes to a coherent understanding of the individual's disease and illness, rather than looking for a discrete somatic or psychological.

As was noted in Chapter 2, the aetiology of chronic idiopathic facial pain is multifactorial. Although, new evidence on pain neurobiology, such as central sensitisation, neuron plasticity, the wide dynamic range of neurones, neurotransmitter and membrane receptors has been emerging, but these can only partly explain pain mechanisms and suggest a possible hypothesis for chronic idiopathic facial pain. The natural course of chronic idiopathic facial pain has not yet been completely elucidated, and what is lacking are specific prognostic factors. There are few evidence based treatments; although many treatments have been claimed to have equal success. What is clear is that treatment should be reversible and non-invasive. Hence there are many controversial issues to be resolved by appropriately designed studies.

In Chapter 3, we described the Eastman paper-based Facial Pain Proforma (FPP) which is a semi-structured questionnaire modified from the well-established one which was originally developed by Professor Malcolm Harris. This was used as a format for collecting patient data for the electronic medical record. The paper-based FPP consists of regions, and areas within regions that are all predetermined. The clinician has the flexibility to move across areas and regions according to the flow of the history. There are also fixed open-ended questions with no predetermined response. The paper-based Facial Pain Proforma is documented in Appendix A.1. We have tested the content validity of the paper-based Facial Pain Proforma by asking a panel of 3 experts including 2 pain specialists and a clinical psychologist to grade the diagnostic value of each item in the proforma. A top grade consensus was reached on the clinical parameters of the pain history and the clinical data in the examination (excluding the clinical psychologist). However, those data of the family history

consisting of marital, parental, children, and sibling relationship were seen by both the psychologist and one pain specialist as being intrusive. This view was at variance with the observation that family conflict is one of the major stressors that is associated with chronic pain such as shown in the model of low back pain (Schwartz, Slater, & Birchler 1996) and tension headache (Aromaa, Sillanpaa, Rautava, & Helenius 2000). Also this was emphasised by the literature review of chronic pain studies, again in chronic low back pain, which demonstrated that psychosocial characteristics are better in predicting the chronicity of pain than clinical or physical factors (Turk 1997). Unfortunately, some patients feel the issue of family relationships is irrelevant in the context of her/his chronic orofacial pain, hence the need to explain this in a sensitive way to patients in order to acquire their support. What emerged was that the debate on what was intrusive revealed marked subjective bias and also lead to important omissions in data collection. Although based on a group of only 3 clinicians (2 pain specialists and a clinical psychologist) the qualitative outcome proved to be invaluable. By contrast the questions in the proforma can induce consistent answers either within (intra-rater reliability) or between interviewers (inter-rater reliability). We have accepted previous studies using the proforma for such reliability.

To investigate the completeness of the conventional free-hand history in comparison to a paper-based Facial Pain Proforma, we conducted a retrospective study and examined the data items recorded in the free-hand medical records of pain specialists, oral and maxillofacial registrars, senior house officers, and postgraduate oral and maxillofacial surgery students. The results revealed that the free-hand medical history was illegible with many omissions of clinical data. Though, the medical record of the pain specialist was not complete, there was a leap from the history to diagnosis. However, we know that the accuracy of data interpretation leading to the diagnosis and the thoroughness of data collection are not dependent on one another (Elstein & Schwatz 2002). Medically trained surgeons produced a good medical history data and examination but often overlooked important related pain features especially psychosocial data. Diagnostic decision making is not well understood and is still being studied in the field of cognitive psychology. Current evidence suggests that the clinician makes a diagnosis using several processes

depending on the difficulty of the case and the clinicians' knowledge and experience as reviewed in Chapter 5. However omissions can be important, for instance complete medical data is not only used for the diagnosis but also for patient care and ongoing management. Our study also revealed that postgraduate students were often patient-lead when taking history in the belief that it was appropriate. The outcome could be irrelevant data with misleading diagnostic conclusions.

From the results of our study and other researchers on the incompleteness of the free-hand medical record, we strongly believe that employing a semi-structured questionnaire such as the Facial Pain Proforma would provide a good history and also guide the novice in taking a pain history.

The traditional paper-based medical record can pose many problems, for example the scatter of medical records among departments, the need of a document summary of the encounter, the problem of only being viewed at one place at a time, the need to be transcribed into a computerised format for data analysis, difficulty in retrieval, and not being interactive. The free text style is also often illegible, incomplete, inaccurate, and ambiguous. Also it is incapable of handling well, the increasing clinical data due to the long life expectation of the population and medical advances. Therefore, in Chapter 4, computing technology was introduced to explore the opportunity for data management. Hence, an electronic medical record was constructed using the paper-based Facial Pain Proforma as a foundation. This electronic medical record was used for collecting and storing patient pain history data. It can later be extended to function as a decision support system for the diagnosis of chronic idiopathic facial pain. This electronic medical record was called Electronic Eastman Pain Proforma (EEPP). The organisation of the content in the electronic medical record is different from the paper-based version both conceptually and in physical design. Microsoft Access 97, a commercial relational database management system, was employed to construct the electronic medical record. There are 2 fundamental components of the electronic medical record: the database and the data entry form interface. The database is a repository to store data whereas the form interface is used for patient data entry. The concept of the database design is based on a Relational Database Management System in which the data values are stored in tables arranged in

rows and columns like a spreadsheet using special concepts named “entity-relationship” and “normalisation” for data value arrangement; and “entity integrity” to uniquely identify each record in the table. These tables are related to each other using relationships that can be used for cross-references named “referential integrity”. The system architecture of EEPP is such that the backend contains all database tables and the front-end all data entry forms and the Visual Basic for Applications (VBA) code. All related clinical data were stored in the same table. For example patient demographic data were stored in table “patient” and pain history data were stored in table “pain history”. The form interfaces of the EEPP were manually created and used for data entry into the database tables. VBA code was employed in the form interface for enhancing the user friendliness and managing data. To facilitate data entry and memory, clinical data items were presented to the user as a list of related data such as a list of symptoms, a list of examination findings, and a list of medication and these lists were hidden by “form controls” from which they could be viewed when required. This interactive design also made the medical record more compact and better organised than the paper-based proforma. To prevent data entry error, we set soft data validation for essential data such as patient identity, hospital number, and name. The method of data entry was to have the user directly enter the patient’s data using a light pen touch by tabbing on the screen.

The EEPP was then validated to explore the acceptability to clinicians and patients for pain history taken in the consulting rooms of the Facial Pain Clinic at the Eastman Dental Hospital. We found that the use of the computerised medical record for taking the pain history in the consulting room did not result in a decrease of the patient’s satisfaction in comparison to free-hand and paper-based history taking when measured by the Consultant Satisfaction Questionnaire (Baker 1990) in all 4 scales, “general satisfaction”, “professional care”, “depth of relationship”, and “perceived time”. Although we expected that the use of EEPP would take longer time (22 minutes) than free-hand history taking (13 minutes) because of the increasing number of questions to be asked, but we did not expect that the time for history taking of the EEPP was longer than paper-based Facial Pain Proforma (18 minutes) because the contents in EEPP were transcribed from the paper-based proforma. The reasons may be that clinicians were not acquainted with the computerised system and light pen

touch transcription, the training time was too short (only one session), and system design imperfect. In addition, nearly all the clinicians took histories from only 5 cases for the EEPP and the first to the third case usually took longer time revealing the effect of a learning curve. Although the increase of consultation time may be seen as a drawback to the use of a computer since patient satisfaction does not increase when compared to not using computer in general practice (Richards, Sullivan, & Ross 1998). However, what should not be overlooked is the increased quality of clinical data content as clearly shown in a cross-sectional survey on general practice medical records in the Trent region (Hippisley-Cox et al. 2003). Clinicians were positive about the concept of the electronic medical record. The design interface was rated as good measured by a modified Questionnaire for User Interface Satisfaction, however, some clinicians felt that the system was rigid and the overall mark for EEPP was rated at 2.8 out of 4. We felt that a successful electronic medical record needs to have a flexible user friendly interface, a display of patient summary, and generate a patient summary report, and letter. The implementation of a graphical anatomical diagram, a tooth diagram and a family tree diagram would also facilitate data entry. Such an effective database and user interface is a major task to be further developed. The current electronic medical record and database will still serve for collecting patient data and establish a facial pain database and so can be used for other objectives such as clinical care, audit, research, education, and support the diagnosis as a decision support system.

Chapter 5; In the literature since 1973, there have been only two computerised diagnostic systems that could provide a range of differential diagnoses of facial pain and headache i.e. the system for the diagnosis and treatment planning of craniofacial pain (Leonard, Robert, Fast, & Mahan 1973) and RHINOS – the system for the diagnosis of facial pain and headache (Matsumura et al. 1986). Several other diagnostic systems are those which support the diagnosis of dental pain. All these systems operated in stand alone fashion; the users had to enter data, mostly typing via keyboard, as required by the system then a list of diagnoses was given. The systems employed a varied range from rule-based approaches to mathematical algorithms (such as pattern recognition and Bayes' theorem) to generate the diagnosis (see Chapter 5); however none of the diagnostic systems have been used routinely in the clinical setting. The possible

reasons are that these systems were built and used without considering the need to integrate with the routine daily work of the clinician caused clinicians extra work to enter patient data by typing in order to get a diagnostic list; and was considered tiresome. Also the computers used were slow and did not have a friendly graphic user interface. A systematic review of controlled clinical trials assessing the effects of computer-based Clinical Decision Support Systems (CDSS) from 1974 to 1998 on clinicians performance and patient outcomes (Johnston, Langton, Haynes, & Mathieu 1994) (Hunt, Haynes, Hanna, & Smith 1998) revealed the benefit of using the computer-based CDSS in preventive care (e.g. generating letters to remind patients for vaccination), adjusting and calculating drug dosage, and the general clinical management of patients (e.g. generating a prompt warning for a significant circumstance of a particular patient to the clinician). Their review revealed only a slight improvement in the diagnosis from CDSS and these CDSS were usually operated in stand alone fashion with manual entry of the data. Hence, we postulate that a Decision Support System that is integrated electronically into the clinical task is more likely to be successful than those used stand alone.

We identified our Decision Support System as an active one that takes patient data into its consideration and generates case-specific advice (Wyatt & Spiegelhalter 1990b). Generally, the basic components of the diagnostic decision support system consist of the knowledge base for the diagnosis, the inference engine, and the user interface and database. Taking all these into consideration, we therefore modelled our diagnostic decision support system to have (1) the electronic medical record (containing entry form interfaces and patient database), (2) integration with the inference engine and, (3) the knowledge based decision tree. The development of our diagnostic decision support system also conforms to the national Electronic Medical Record project of the United Kingdom government for which the complete implementation of a national Electronic Medical Record in all NHS organisations is targeted by year 2008. A set of specific standards for the national Electronic Medical Record and steps for developing the national Electronic Medical Record are noted in Chapter 4.

By focusing on the decision support system, we explained the definition, characteristics, structure and techniques to build such a system. The most

striking and essential contribution was that a knowledge based decision tree for the diagnosis of chronic idiopathic facial pain was constructed and it was called “the hand-crafted decision tree”. This diagnostic knowledge was acquired from the orofacial pain expert, Professor Malcolm Harris. The knowledge base is the most important part of any Decision Support System and this makes a distinction from a conventional software program. Knowledge can be acquired from a human expert or published literature in that domain. The published data is often taken from a critical review or a meta-analysis. On the other hand, the expert knowledge has been developed over a long period of observation, analysis, synthesis, from real patient cases, and current literature. Although this method is inevitably subject to bias we argue that the expert’s knowledge is still of considerable value in an area lacking solid evidence to support a diagnosis such as orofacial pain. Also the human expert skill knows how to use what is known which can be called “good clinical judgement” (Musen, Shahar, & Shortliffe 2001). This must be distinguished from the simple memorisation of factual knowledge or data from the literature.

The diagnostic knowledge is represented in the decision tree (or flow chart) format. The method for representing this knowledge is varied with inherent advantages and disadvantages for every method. Although the hand-crafted decision tree has explicit symbolic knowledge representation which is easy to understand, it is rigid and with limited choices and if it proceeds in the wrong way, it is difficult to turn back. This will cause frustration for the clinician and can cause the program to halt abruptly. We considered the hand-crafted decision tree to be a good experimental start in the construction of a decision support system for the diagnosis of chronic idiopathic facial pain. Moreover, the decision tree structure facilitates the construction of “if-then” rules for diagnosis and both can be employed in the system. The hand-crafted decision tree consisted of 6 trees based on the facial topographical area as follows;

- Frontal
- TMJ & parietotemporal
- Maxilla
- Mandible
- Teeth & alveolar
- Oral mucosa

The details of these 6 decision trees can be viewed in the Chapter 5. Bearing in mind that the criteria for the diagnosis of atypical facial pain, facial arthromyalgia, and oral dysaesthesia for some have not yet achieved a consensus. Our knowledge model for the diagnosis of chronic idiopathic facial pain does not intend to propose absolute criteria but instead establish a clinical diagnostic pathway. This hand-crafted decision tree can be used either manually or integrated in a decision support system. As was discussed in Chapter 5, all basic diagnostic tests such as thermal test (hot/cold), percussion test, Electrical Pulp Test (EPT), plain film radiography, and TMJ palpation, suffers from inadequate reliability and validity. This will definitely affect any diagnosis. Uncertainty is inherited and is commonly found in medicine. This also can affect the accuracy of the diagnosis. Moreover, the diagnosis which was based on a clinical history as a mainstay may inherit weaknesses due to incomplete clinical information (anamnesis), or an inappropriate selection of clinical parameters. Diagnostic decision support systems seem to be therefore difficult to develop. The reasons are that; (1) diagnosis reasoning and problem solving are complicated to characterise into explicit transparent knowledge; (2) the knowledge representation method (e.g. flow chart, decision tree, semantic net work) may have inherited deficiency; (3) the current techniques in computerised science is insufficient to capture the process of cognitive thinking and problem solving. Also issues of constraint in the clinical environment have to be addressed and studied for achieving a successful CDSS.

We have demonstrated that the knowledge for the differential diagnosis of CIFP acquired from the expert can be modelled into a decision tree format.

In chapter 6, we introduced the “Knowledge Discovery Database (KDD)” or “Data Mining” to see how they can contribute to the diagnosis CIFP. KDD is defined as the process of discovering patterns or relationships in data. KDD typically deals with large data sets that have already been collected for some purpose other than data analysis. The learning algorithms used in KDD for finding and describing patterns in data are developed within a field of computer science known as “machine learning”. This is concerned with computational methods that can automatically acquire knowledge by induction from examples. In our study, we employed a decision tree learning algorithm to create a

diagnostic decision tree from 280 patients' data set. This is "the induced decision tree" to be used for the diagnosis of CFP.

The results showed that this induced decision tree can capture the functionality of the clinicians' classification scheme. The accuracy, performance, sensitivity, specificity, positive/negative predictive ratio and positive/negative likelihood ratio of the model were all measured by testing it on unseen cases using the clinician's diagnosis as a gold standard. The accuracy rate was high (88% and 85.7%) with high discriminative performance (see Tables 6-9, and 6-12 and discussion). Also when the "if-then" rules for a diagnosis were generated (see example in Figure 6-10), only those rules with a minimum of 3 patients and a minimum confidence of 0.6 were selected. Confidence is calculated by the number of patients for which the diagnosis is true divided by the number of patients at the leaf node (terminal node).

These induced decision trees are sparse and smaller than hand-crafted decision trees since they use a small number of attributes, between 8 to 15 from a total of 117 attributes. In all the decision trees generated, there are attributes which act as good classifiers for the diagnosis. These good classifiers are those that occur high in the decision tree (i.e. near the root or base of the tree) and those which frequently appear in the tree. In general, decision trees can be viewed as suggesting a series of hypotheses which may explain the diagnosis of CFP in various situations. In this study, the attributes that were selected by the induced decision tree models were similar to those used by clinicians as important predictors of the diagnosis. For example, the main complaint of pain, aggravation by jaw-movement or biting/chewing, and tender masticatory muscle on palpation are used for the diagnosis of facial arthromyalgia. However, some suggested hypotheses can be viewed as questionable. For example, when nausea is an associated symptom, or subjective numbness an associated symptom as classifiers for atypical facial pain. Such a suggested hypothesis would require further objective investigation.

There are limitations in this study. The accuracy of the model suffers bias because the test data set were collected from the same clinical setting as the training data set. Moreover, the data in this study were obtained from the patients presenting to a very specialised Facial Pain Clinic. This introduces a

referral bias since our data set contains only patients who have been screened in the especially primary care setting. Hence these patients were mostly chronic idiopathic facial pain rather than a variety of dental pains which are more common elsewhere. It remains to be seen whether our models will perform well in other situations where the prevalence of chronic idiopathic facial pain is presumably lower.

The induced decision tree can be improved by increasing the number of patients, reducing redundant data and aggregating data in groups before data mining. The number of cases should be enough for the machine learning algorithm to induce sensible “knowledge”. No specific rule has been established but a rule of thumb indicates that the number of cases should be 10 times more than the number of attributes in the data set. Although our data set contained 280 cases and 117 attributes, the results were considered to be good. Theoretically one would need a thousand patients to improve the outcome using the same number of attributes.

The decision pattern of the model is also useful as a learning aid for practitioners. The implication is that by employing a knowledge discovery database and data mining techniques, time would be reduced for knowledge acquisition compared to the human expert.

In Chapter 7, the hand-crafted decision tree for the diagnosis of chronic idiopathic facial pain was validated using the clinicians diagnosis as a gold standard although we were aware of no perfect diagnostic gold standard in medicine. Also we tested the diagnostic pathway to find errors, inconsistencies, and incompleteness. Although Kappa statistics is a standard means to measure agreement between two diagnostic methods, this could not be applied in our study because of discrepancies in diagnosis between the hand-crafted decision tree and the clinician. We found that the accuracy of the hand-crafted decision tree diagnosis was 84.8% which was not significantly less than the two induced decision tree models (85.7% and 88%). This justifies using the induced decision tree model because of the comparable accuracy to that of the expert and the facility of automatically inducing it from a patient data set compared to acquiring the knowledge from the expert. However, hand-crafted decision trees provide a more reasonable and comprehensible structure than those of machine learning.

Our hand-crafted decision model for the diagnosis of CIFP captured the content of the expert domain i.e. his pain knowledge, and represented it in such a way that it is understandable and also leads to the diagnosis of orofacial pain. The accuracy of the diagnosis is quite good at 84.8% and shows a promising capability given further development.

This thesis has explored the components of the computerised decision support system for the diagnosis of CIFP. In particular, the knowledge base for the diagnosis, the system database as a repository of patient data, and the interfaces for interactive collecting of patient data. The knowledge for pain diagnosis was acquired from the expert in orofacial pain and was represented in decision tree form. These decision trees were also transcribed into sets of if-then rules for the purpose of validation and to improve human readability. The Electronic Eastman Pain Proforma database and interface also functions as a medical record.

8.2. Future work

The study showed great potential to develop a computerised decision support system for the diagnosis of chronic idiopathic facial pain, but further work is required to fulfill the objectives.

- (a) The hand-crafted decision trees need minor modifications as noted in Chapter 7. Then a further validation with a variety of oral and dental pains in another environment, needs to be done to confirm its diagnostic capability and transferability.
- (b) It would be interesting to test the transferability of the decision tree to different clinical setting such as primary and tertiary care units, different cultures, and different socioeconomical settings because all these factors are known to influence pain behaviour. The scale of such a study can be either, (i) a small scale with mutual collaboration of clinicians from a few institutes; A small scale can be nationally or internationally between 2 or 3 clinical settings such as the facial pain/oral medicine clinics, and Primary Treatment Units with the appropriate skilled resources; or (ii) a large scale involving a broad array of multinational clinicians; A large scale involving multinational clinicians can use the internet as a central coordinating

centre and e-mail discussion groups such as the CARE (Clinical Assessment of the Reliability of the Examination) website (Straus, McAlister, & Sackett 2003) which can be viewed at <http://www.carestudy.com/CareStudy/Default.asp>. This web-based international collaborative group has proved to be success as seen from publication (Straus et al. 2000).

- (c) There are several aspects of the EEPP that can be improved as was noted in Chapter 4. For example, a summary document function can be added with the addition of a new interface to present a comprehensive summary of all the history, examination, diagnosis, and treatment. This interface would be accessed by clicking the command button in the clinical data entry interface after the user has filled in all the clinical data. This summary would also be printed out as a record. The Microsoft Access software can share and exchange data with other Microsoft Office software such as Microsoft Word and Excel. This will allow linking the Access database, Word processing, and Excel spreadsheet program. We also identify other useful applications for patient management such as referral and discharge letter generation by using Microsoft word, patient data analysis by using Microsoft Excel, and imaging archive to keep the radiography, clinical imaging. This work can be developed further to the extent of patient-centre folder aiming to integrate representative health care data from disparate clinical sources and provide a uniform, high quality multi-media clinical record system to be deployed at the point of care delivery. This will require technical expertise to support the desired functionality. Such work needs to be developed using 2 strategies, (i) employing a commercial software firm to work in partnership on the technical issues, and (ii) development in an academic environment as a PhD. project or MSc. project in computer science/information technology/medical informatics.
- (d) Expert knowledge for the diagnosis of chronic idiopathic facial pain needs to be integrated into the EEPP so that the system can automatically capture patient data and evaluate it against the expert knowledge to provide the diagnosis. Again this can be done using 2 strategies as previously mentioned. The PhD. project should emphasise the integration

of the medical record and decision support system using the hand-crafted decision tree as a knowledge base.

- (e) The study of machine learning techniques and Knowledge Discovery Database or Data Mining open up interesting possibilities for automatically inducing the diagnostic knowledge from a training patient data set. It would be interesting to collect more patients or pool patients to achieve the knowledge. Moreover, it is interesting to test machine learning techniques such as neural networks, unsupervised learning techniques for cluster analysis, and statistics technique such as multivariate analysis with this patient data set to find out the best model for diagnosis. This can also be done with the data from (a).

Finally, as mentioned in the content review in many chapters, uncertainty is ubiquitous in medical data. There is a challenge to model the uncertainty in diagnostic clinical decision making using mathematics. Our study needs the implementation of an algorithm to deal with uncertainty.

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APPENDIX A

THE QUESTIONNAIRES

This Appendix provides the detail of the questionnaires used in this research including; (1) the Facial Pain Proforma (FPP), (2) the questionnaire for clinicians to rate the value of clinical data items in the FPP, (3) the Consultant Satisfaction Questionnaire (CSQ), and (4) the modified Questionnaire for User Interface Satisfaction (QUIS).



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FACIAL PAIN PROFORMA

HISTORY TAKING

I. PAIN HISTORY

PLEASE CIRCLE AS APPROPRIATE

1. What is/are your problem(s)?

- ☐ Pain (please indicate in the diagram 2A and 2B; and specify location of pain from the list 2C.)
- ☐ Noise when opening mouth (e.g. clicking or crepitus)
- ☐ Limited mouth opening
- ☐ Sticking or locked jaw
- ☐ Bite discomfort
- ☐ Disturbance of oral sensation (eg. Burning)
- ☐ Taste change
- ☐ Salivation
- ☐ Denture intolerance
- ☐ Others (specify).....

2. Where is the pain (or problem) ?

Please draw the pain area and distribution in the diagrams.

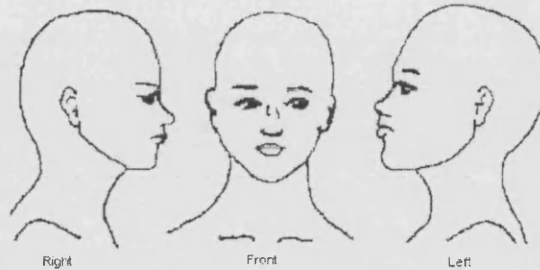
A. Head and Neck

☐ applicable

☐ not applicable



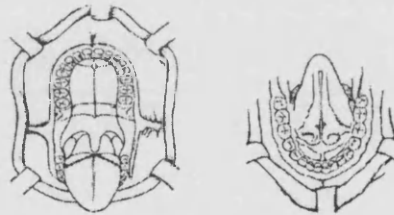
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B. Intraoral

☐ applicable

☐ not applicable



C. Please circle the location of the pain

- | | |
|-------------------------|----------------------------|
| 1) dento-Alveolar | 7) temporomandibular joint |
| 2) gum | 8) eyes |
| 3) lips | 9) ears; |
| 4) tongue | 10) face |
| 5) upper jaw (maxilla) | 11) head |
| 6) lower jaw (mandible) | 12) neck |
| | 13) other (specify)..... |

3. Pain (or condition) distribution:

- ①.NA ②.unilateral ③.bilateral (L = R, or L > R, or R > L)



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4. How long have you had pain (or condition) since the first onset?
.....①.days ②.weeks ③.months ④.years
5. What is the quality of the pain like?
① NA ⑤ sharp or stabbing
② discomfort ⑥ electric like
③ dull ache ⑦ burning
④ throbbing ⑧ tingling (pin and needle)
6. How would you rate the intensity of pain (or condition)?
① NA ②.mild ③.moderate ④.severe ⑤. variable
7. What is the pattern of pain (or condition)?
①.NA ②.constant ③.intermittent
8. *If intermittent*, how frequent are the episodes? (leave if constant)
Every.....① minute ②.hourly ③.daily ④.weekly ⑤ monthly
9. *If intermittent*, how long does the pain (or condition) last?
..... ①.NA ②.minutes ③.hours ④.days ⑤.weeks ⑥ months
10. When does the pain (or condition) usually come?
①.NA ②.morning ③.afternoon ④.evening ⑤.anytime
11. What is the progress since onset?
①.same ②.improving ③.worse
12. How does the pain (or condition) effect to sleep?
①.prevents ②.disturbs ③.no effect
13. Did any event occur at the onset of the pain (or condition)? (You may choose more than one.)
☐ nil (spontaneous) ☐ illness
☐ dental treatment ☐ physical trauma
☐ general anaesthesia operation ☐ emotional factors
☐ other (specify).....
14. What can make the pain (or condition) worse? (You may choose more than one.)
☐ nil ☐ hard food
☐ opening wide ☐ hot food/drink
☐ biting ☐ cold food/drink
☐ chewing ☐ weather change
☐ yawning ☐ emotion tension (stress)
☐ talking ☐ tired (fatigue)
☐ swallowing ☐ noise
☐ bodily movement ☐ light



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☐ other
(specify).....

15. What can make the pain (or condition) better? (You may choose more than one.)

- | | |
|--|---|
| <input type="checkbox"/> nil | <input type="checkbox"/> rest and relaxation |
| <input type="checkbox"/> physical pressure | <input type="checkbox"/> bite guard |
| <input type="checkbox"/> food | <input type="checkbox"/> analgesics(specify)..... |
| <input type="checkbox"/> alcohol | <input type="checkbox"/> other medications (specify)..... |
| <input type="checkbox"/> application of cold | <input type="checkbox"/> other factors (specify)..... |
| <input type="checkbox"/> application of heat | |
| <input type="checkbox"/> sleep | |

16. What are the other associated symptoms and signs to this pain (or condition)? (You may choose more than one.)

- | | | | |
|--|---|--|---|
| <input type="checkbox"/> nil | <input type="checkbox"/> disturbed vision | <input type="checkbox"/> nausea | <input type="checkbox"/> other (specify) :..... |
| <input type="checkbox"/> swelling | <input type="checkbox"/> sweating | <input type="checkbox"/> dizziness | |
| <input type="checkbox"/> redness (hyperemia) | <input type="checkbox"/> lacrimation | <input type="checkbox"/> trigger point | |
| <input type="checkbox"/> numbness | <input type="checkbox"/> nasal stuffiness | <input type="checkbox"/> dry mouth | |
| <input type="checkbox"/> tinnitus | <input type="checkbox"/> nasal discharge | <input type="checkbox"/> altered taste | |
| <input type="checkbox"/> fullness in the ear | <input type="checkbox"/> fever | <input type="checkbox"/> altered smell | |

17. Are you aware of clenching your teeth?

☐ no ☐ yes ☐ don't know

18. Have you had any previous consultation for this problem? If so, by whom, when and the result?

Month/year

- | | |
|---|-------|
| <input type="checkbox"/> nil | |
| <input type="checkbox"/> GDP | |
| <input type="checkbox"/> GMP | |
| <input type="checkbox"/> oral surgeon | |
| <input type="checkbox"/> orthodontist | |
| <input type="checkbox"/> neurologist | |
| <input type="checkbox"/> ENTsurgeon | |
| <input type="checkbox"/> rheumatologist | |
| <input type="checkbox"/> psychiatrist | |
| <input type="checkbox"/> pain specialist | |
| <input type="checkbox"/> other (specify)..... | |



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19. Have you had any previous treatment for this problem?

If so, what treatment, and when?

☐ Nil

☐ Medication

☐ analgesics (specify) :

☐ antibiotics (specify) :

☐ tranquilizers (specify) :

☐ antidepressants (specify) :

☐ anticonvulsant (specify) :

☐ others (specify) :

☐ Dental Treatment

☐ occlusal splint

☐ fillings

☐ extirpation of dental pulp

☐ forceps extraction

☐ surgical extraction

☐ apicoectomy

☐ denture

☐ Physiotherapy (specify) :

☐ Ultrasound

☐ Short-wave diathermy

☐ Osteopathy

☐ Acupuncture

☐ TENS

☐ Psychological Treatment (specify) :

☐ Surgery

☐ TMJ injection

☐ arthroscopy/arthrocentesis

☐ trigger point injection

☐ TMJ operation

☐ arthrotomy

☐ Other (specify) :

20. Present and Past Pain Related History :

☐ Nil

☐ headache

☐ migraine

☐ neck pain

☐ back pain

☐ chest pain

☐ Irritable bowel syndrome

☐ endometriosis

☐ pruritus



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- | | | |
|---|--|--|
| <input type="checkbox"/> earache | <input type="checkbox"/> rheumatoid arthritis | <input type="checkbox"/> temporal arteritis |
| <input type="checkbox"/> whiplash | <input type="checkbox"/> ankylosing spondylitis | <input type="checkbox"/> multiple sclerosis |
| <input type="checkbox"/> arthralgia | <input type="checkbox"/> myalgic encephalomyelitis | <input type="checkbox"/> diabetes |
| <input type="checkbox"/> osteoarthritis | <input type="checkbox"/> shingles | <input type="checkbox"/> other (specify) |
| <input type="checkbox"/> dysmenorrhea | | |

II. Medical History

21. How is your general health?

- ☐ good ☐ satisfactory ☐ poor

22. Present Medical History :

- ☐ Nil
☐ Yes (state any illness which you currently have)

.....

23. Current Medication :

- ☐ Nil
☐ Yes (state the medication which you currently have)

.....

24. Past Medical History :

- ☐ Nil
☐ Yes (state the illnesses which you have had)

.....

25. Past Hospitalisation(s) and/or Operation(s) :

- ☐ Nil
☐ Yes (state the hospitalisation or operation)

.....



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FACIAL PAIN PROFORMA

III. PSYCHOSOCIAL HISTORY :

26. What is your marital status? (more than one choice may be possible)

- ① single ④ separated
② married ⑤ divorced
③ partner ⑥ widowed

27. What is your employment status?

- ① student ④ unemployed (duration :.....reason :.....)
② housewife ⑤ retired
③ employed

28. What is your occupation?

Occupation:
(if unemployed or retired, state last occupation)

29. Do you like your job? :

- ① yes ② no (state reason :.....)

30. What is your country of origin? And What is your ethnic group?

Country of origin:.....Ethnic group:.....

31. Do you smoke?

- ① no ② yes (.....cigarettes/day)

32. Do you drink alcohol?

- ① no ② yes (.....units/week)

33. Do you use any recreational substance or drugs?

- ① no ② yes (specify :.....)

34. Do you consider yourself more calm than tense?

- ① no ② yes

35. Do you worry?

- ① no ② yes (state the reason:.....)

36. Are you depressed now?

- ① no ② yes

37. Have you had a depressive illness?

- ① no ② yes (specify when and treatment)

When:.....

Treatment:.....

38. Do you have any current problems?

- ☐ Nil
☐ Health
☐ Financial



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FACIAL PAIN PROFORMA

- ☐ Marital (family life)
- ☐ Employment
- ☐ Accommodation
- ☐ Spouse new job or unemployment
- ☐ Assaults (robbery, theft, rape)
- ☐ Change in sleeping pattern (more or less sleep)
- ☐ Serious disappointment
- ☐ Litigation

IV. Family History

39. Parents :

a. Father

①.alive

health : ① good ② satisfactory ③ poor (specify :.....)

②.dead

cause :..... year of death :.....

b. Mother

①.alive

health : ① good ② satisfactory ③ poor (specify:.....)

②.dead

cause :..... year of death :.....

c. Relationship of parents :

① good ② satisfactory ③ poor ④ separated ⑤ divorced

d. If divorced (leave if not applicable)

① father remarried: ① yes ② no

② mother remarried: ① yes ② no

e. Emotional impact (from bereavement, ill-health, or poor parents' relationship)?

① nil ② mild ③ moderate ④ great

40. Spouse : ☐ Applicable ☐ Not applicable

a. Patient's partner:

①.alive

health : ① good ② satisfactory ③ poor (specify:.....)

②.dead

cause :..... year of death :.....

b. Current marriage/relationship:

Duration of current relationship :.....months/years

① good ② satisfactory ③ poor ④ separated (since.....) ⑤ divorced (since.....)



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FACIAL PAIN PROFORMA

c. Previous marriage/relationship:

Reason for ending relationship: ① separated ② divorced ③ death of partner

Emotional impact: ① nil ② mild ③ moderate ④ great

d. Emotional impact: (from bereavement, ill-health, or poor current relationship) ?

① nil ② mild ③ moderate ④ great

41. Children : ☐ Applicable ☐ Not applicable

a. Number of children:

Son(s): Daughter(s):

b. Children:

① alive

health : ① good ② satisfactory ③ poor (specify:.....)

② dead

cause : year of death :

c. Children Health:

① good ② satisfactory ③ poor (specify:.....)

d. Relationship with children :

① good ② satisfactory ③ poor

e. Behaviour of children :

① good ② satisfactory ③ poor

f. Emotional impact (from bereavement, ill-health, relationship, or behaviour)?

① nil ② mild ③ moderate ④ great

42. Siblings : ☐ Applicable ☐ Not applicable

a. Number of Sibling,

Brother(s): Sister(s):

b. Siblings:

① alive

health : ① good ② satisfactory ③ poor (specify:.....)

② dead

cause : year of death :

c. Siblings Relationship:

① good ② satisfactory ③ poor

d. Emotional impact from bereavement and/or ill-health and/or relationship?

① nil ② mild ③ moderate ④ great



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FACIAL PAIN PROFORMA

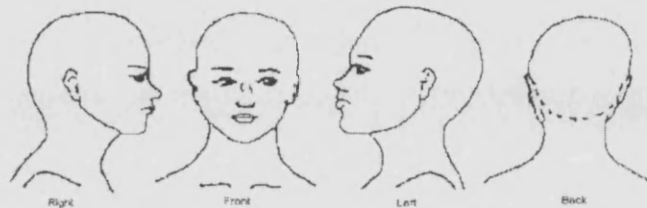
EXAMINATION

1 CRANIAL NERVE EXAMINATION

- ① Not done
② Normal
③ Findings (state the abnormality)

.....
.....

2 EXTRAORAL EXAMINATION : (INDICATE ON DIAGRAM)



- 2.1 Swelling : ① no ② yes (specify.....)
2.2 Lymphadenopathy : ① no ② yes (specify.....)
2.3 Tenderness on palpation: ① no ② yes (specify.....)

3 TMJ. PALPATION

3.1 TMJ-pain on palpation (digital analogue)

	<u>1.Right</u>				<u>2.Left</u>			
Severity	0	1	2	3	0	1	2	3

3.2 Click or crepitus

	<u>nil</u>	<u>Yes</u>
a. right on opening :	<input type="checkbox"/>	<input type="checkbox"/>
b. right on closing :	<input type="checkbox"/>	<input type="checkbox"/>
c. left on opening :	<input type="checkbox"/>	<input type="checkbox"/>
d. left on closing .	<input type="checkbox"/>	<input type="checkbox"/>



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FACIAL PAIN PROFORMA

3.3 Muscle pain on palpation.

	<u>1.Right</u>		<u>2.Left</u>	
a. Temporalis	0	1	0	1
b. Masseter	0	1	0	1
c. Lateral pterygoid	0	1	0	1
d. Temporalis tendon	0	1	0	1
e. Sternocleidomastoid	0	1	0	1
f. Submandibular region	0	1	0	1

4 MANDIBULAR MOVEMENT :

4.1 Opening Pattern

① Straight ② R deviation ③ L deviation ④ R corrected ⑤ L corrected

4.2 Maximum Opening =mm.

5 INTRAORAL EXAMINATION

5.1 General oral hygiene : ① poor ② satisfactory ③ good

5.2 Teeth present (cross out the missing teeth)

RIGHT																LEFT															
1																														2	
	8	7	6	5	4	3	2	1									1	2	3	4	5	6	7	8							
4																														3	

5.3 Abnormal dental finding(s):

- ☐ Nil abnormal
☐ Attrition (mild/marked) (specify :.....)
☐ Dental caries (specify:.....)
☐ Pocket formation (specify:.....)
☐ Mobility (specify:.....)
☐ Tenderness (specify:.....)

5.4 Special test(s):

- ☐ NA
☐ vitality pulp test (positive / negative)
☐ cold test (positive / negative)
☐ hot test (positive / negative)
☐ wedging test (positive / negative)
☐ dye test or transillumination test (positive / negative)



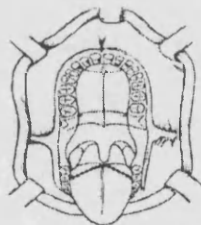
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5.5 Prostheses:

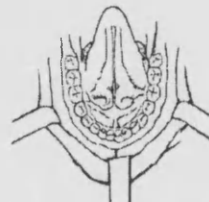
- ☐ NA
☐ satisfactory
☐ unsatisfactory (state reason):.....

5.6 Soft tissue finding(s): (indicate in diagram)

- ☐ Nil abnormal
☐ Buccal mucosa:
 ① ridging ② hyperkeratosis ③ maceration
☐ Tongue:
 ① crenation ② erosion ③ ulcer ④ hyperkeratosis
☐ Floor of mouth
 ① atrophy ② erosion ③ ulcer ④ hyperkeratosis
☐ Gingiva
 ① atrophy ② erosion ③ ulcer ④ hyperkeratosis
☐ Palate
 ① atrophy ② erosion ③ ulcer ④ swelling
☐ Oropharynx
 ① atrophy ② erosion ③ ulcer ④ swelling
☐ Lip
 ① atrophy ② erosion ③ ulcer ④ hyperkeratosis ⑤ swelling



Upper



Lower

6. INVESTIGATIONS

6.1. Radiography

A. OPG: ① not done ② normal ③ finding(s)

1. Condyle : ☐ normal ☐ finding(s):
 ① erosion (R / L) ④ osteophyte (R / L)
 ② flattening (R / L) ⑤ fracture line (R / L)
 ③ sclerosis (R / L) ⑥ hypoplasia (R / L)



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②. hyperplasia (R / L)

2. Mandible : ☐ normal ☐ finding(s):

①. radiolucent lesion (specify:.....)

②. radiopaque lesion (specify:.....)

③. fracture (specify:.....)

3. Maxilla : ☐ normal ☐ finding(s):

①. radiolucent lesion (specify:.....)

②. radiopaque lesion (specify:.....)

③. fracture (specify:.....)

4. Antrum : ☐ normal ☐ finding(s):

①. Opacity (specify:.....)

②. fluid level (specify:.....)

B. Periapical film: ① not done ② normal ③ finding(s).

①. impaction/embedded (specify:.....)

②. pulp encroachment (specify:.....)

③. periapical radiolucency (specify:.....)

④. periapical radiopacity (specify:.....)

⑤. root filling (specify:.....)

⑥. retrograde filling (specify:.....)

⑦. alveolar bone destruction (specify:.....)

C. CT scan: ① not done ② normal ③ finding(s) (specify:.....)

D. MRI scan: ① not done ② normal ③ finding(s) (specify:.....)

E. Other radiography (occlusal film, transcranial, Occipito-mental view) and result

.....
.....

6.2 Haematology investigation: ① Not relevant ② Relevant

1. Hb : ① not done ②. normal ③. abnormal

2. FBC : ① not done ②. normal ③. abnormal

3. serum iron : ① not done ②. normal ③. abnormal

4. Transferrin : ① not done ②. normal ③. abnormal

5. Ferritin : ① not done ②. normal ③. abnormal

6. Vit. B12 : ① not done ②. normal ③. abnormal

7. Folate : ① not done ②. normal ③. abnormal

8. ESR : ① not done ②. normal ③. abnormal

9. Autoimmune screening : ① not done ②. normal ③. abnormal



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7 DIAGNOSIS : (CHOOSE AS APPROPRIATE)

- 7.1 Pulpitis and periapical abscess
- 7.2 Periodontal pain
- 7.3 Cracked tooth
- 7.4 Pericoronitis
- 7.5 TMJ internal derangement with reduction
- 7.6 TMJ internal derangement without reduction
- 7.7 Facial arthromyalgia
- 7.8 Atypical facial pain
- 7.9 Atypical odontalgia
- 7.10 Oral dyæsthesia
- 7.11 Phantom bite
- 7.12 Post traumatic stress disorder
- 7.13 Osteoarthritis (Idiopathic degenerative TMJ)
- 7.14 Rheumatoid arthritis of TMJ
- 7.15 Intraarticular ankylosis
- 7.16 Extraarticular ankylosis
- 7.17 Trigeminal neuralgia
- 7.18 Facial migrainous neuralgia
- 7.19 Tension headache
- 7.20 Sinusitis
- 7.21 Migraine
- 7.22 Temporal arteritis
- 7.23 Odontogenic cyst-infected
- 7.24 Intraosseous tumour
- 7.25 Antral carcinoma
- 7.26 Intracranial tumour



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7.27 Anemia (deficiency of Iron, B12, Folate, B complex)

7.28 Ulceration

7.29 Sialadenitis / Sialolithiasis

7.30 Cardiac Ischemia

8 TREATMENT :

- | | |
|---|------------------------------|
| 1 Reassurance with pain handout and discharge | 4.3 antidepressant/sedative |
| 2 Reassurance with pain handout and follow up | 4.4 anticonvulsant |
| 3 Dental Treatment | 5 Surgery |
| 3.1 filling/dressing | 5.1 arthroscopy |
| 3.2 extirpation of dental pulp | 5.2 arthrotomy |
| 3.3 forcep extraction | 6 Physiotherapy |
| 3.4 surgical extraction | 6.1 jaw exercise |
| 3.5 occlusal splint | 7 Psychological treatment |
| 3.6 denture(s) | 8 Salivary substitute |
| 4 Medication | 9 Vitamin supplement |
| 4.1 analgesic | 10 Refer to other specialist |
| 4.2 antibiotic | |

PLEASE FILL SUMMARY ON PAGE 1

A.2. The Questionnaire for Rating the Data Items in the FPP

Please give the score to each clinical data with concerning to the usefulness for the diagnosis and management of orofacial pain. Please mark " / " into the grade that you wish to.

Clinical data	nil 0	rarely 1	likely 2	always 3	Comment
1. Complaint					
2. Area of pain					
3. Pain distribution pattern					
4. Duration since onset					
5. Quality of pain					
6. Intensity of pain					
7. Pattern of pain (constant/intermittent)					
8. Frequency of episodes					
9. Duration of bout of each episode					
10. Time when pain usually come or when pain is worse?					
11. How does pain affect sleep?					
12. Precipitating factors					
13. Aggravating factors					
14. Relieving factors					
15. Associated symptoms and signs					
16. Awareness of clenching teeth					
17. Previous consultation					
18. previous treatment					
19. Progress of pain since onset					
20. Past medical history					
21. Current medication					
22. Pain related past & present medical hx. (e.g. headache, neckache, backache etc.)					
23. Psychosocial hx : Marital status					
24. Psychosocial hx : Employment status					
25. Psychosocial hx : Occupation					
26. Psychosocial hx : Smoking					
27. Psychosocial hx : Drinking					
28. Psychosocial hx : Drug use					
29. Psychosocial hx : Depressive illness in the past					
30. Psychosocial hx : Present depressed?					
31. Psychosocial hx : Calm/tense personality					
32. Psychosocial hx : Worry of anything?					
33. Psychosocial hx : Current problems?					
34. Family hx : Family tree drawing					
35. Family hx : Parents : their health, their alive/death, their relationship, emotional impact to patient					
36. Family hx : Partners : their health, their alive/death, marital relationship, emotional impact					
37. Family hx : Children : their health, their alive/death, relationship with children, behaviour of children, emotional					
38. Family hx : Siblings : their health, their alive/death, emotional impact					
39. Examination : cranial nerve exam					
40. EO : swelling					
41. EO : lymphadenopathy					
42. TMJ : palpation pain					
43. TMJ : click/crepitus					
44. TMJ : muscle pain on palpation					
45. Mandibular movement					
46. Mouth opening measure					
47. IO : Teeth					
48. IO : Mucosa					
49. Radiography					
50. Haemato. / chem. Lab investigation					
51. Diagnosis					
52. Treatment					

A.3. The Consultant Satisfaction Questionnaire (CSQ)



**Oral & Maxillofacial And Biomedical Informatics Department,
Eastman Dental Institute for Oral Health Care Sciences,
University College London**
256 Gray's Inn Road, London WC1X 8LD



17TH May, 2001

Dear Patient,

We are examining 3 different ways to record a pain history. We believe this will help us to obtain the most efficient and accurate history. We welcome your consent to take part in this investigation by agreeing to fill in a simple questionnaire after your consultation. This project will not in any way effect the clinical diagnosis or your treatment.

We are looking forward to your approval.

Yours sincerely

Prof. Malcolm Harris Prof. Peter Hammond Dr. Premthip Chalidapongse

I agree to participate in the pain history project by filling our the satisfaction questionnaire. I have been reassured that the project will not in any way effect either my diagnosis or treatment.

Signature :

Date : / /

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Emeritus Professor in Oral and Maxillofacial Surgery and Honorary Consultant UCLH
Tel : +44 (0) 20 7915 1056
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**Oral & Maxillofacial And Biomedical Informatics Department,
Eastman Dental Institute for Oral Health Care Sciences,
University College London**

256 Gray's Inn Road, London WC1X 8LD



Dear Patient

We would like to know your opinion of this consultation. This would help us to develop and improve our clinical service. Your opinion will not in any way effect the clinical diagnosis or your treatment.

Thank you

Prof. Malcolm Harris

Prof. Peter Hammond

Dr. Premthip Chalidapongse

25/05/2001

Prof. Peter Hammond BA MSc PhD FBMiS
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Consultant Satisfaction Questionnaire

Please tick as appropriate.

	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
1. I am totally satisfied with my visit to this doctor.					
2. This doctor was very careful to check everything when examining me.					
3. I will follow this doctor's advice because I think he/she is absolutely right.					
4. I felt able to tell this doctor about very personal things.					
5. The time I was able to spend with the doctor was a bit too short.					
6. This doctor told me everything about my treatment.					
7. Some things about my consultation with the doctor could have been better.					
8. There are some things this doctor does not know about me.					
9. This doctor examined me very thoroughly.					
10. I thought this doctor took notice of me as a person.					
11. The time I was allowed to spend with the doctor was not long enough to deal with everything I wanted.					
12. I understand my illness much better after seeing this doctor.					
13. This doctor was interested in me as a person, and not just my illness.					
14. This doctor knows all about me.					

	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
15. I felt this doctor really knew what I was thinking.					
16. I wish it had been possible to spend a little longer with the doctor					
17. I am not completely satisfied with my visit to the doctor.					
18. I would find it difficult to tell this doctor about some private things.					
19. The use of a computer in the examination room.					
20. If given a choice, I would prefer a doctor who uses computer.					
21. The doctor seemed to have trouble using the computer					

Other comment please describe below:

.....

.....

.....

.....

Thank you

The short-form questionnaire

Computerised Facial Pain Proforma-Patient Satisfaction Questionnaire

Please indicate your agreement with the statements below by ticking the appropriated box.

	<u>Agree</u>	<u>Disagree</u>	<u>Neutral</u>
1. Computer should be used in the examination room.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. If given a choice, I would prefer a doctor who uses a computer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. The doctor seemed to have trouble using the computer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. The doctor took a thorough history.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. The doctor was willing to listen to all my concerns.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. Other comments, please describe below.

.....

.....

.....

.....

.....

Date : 18/05/01

A.4. The Modified Questionnaire for User Interface Satisfaction (QUIS)

Questionnaire for User Interaction Satisfaction (QUIS)

Please rate your satisfaction of each topic by circle at the number on the scale (1-9).

Section 1 : Overall user reactions

Overall reaction :

Frustrating	1	2	3	4	5	6	7	8	9	Satisfying
Dull	1	2	3	4	5	6	7	8	9	Stimulating
Difficult	1	2	3	4	5	6	7	8	9	Easy
Useful	1	2	3	4	5	6	7	8	9	Useless
Rigid	1	2	3	4	5	6	7	8	9	Flexible

Section 2: Screen design & layout

2.1 Characters on screen is:

Hard to read	1	2	3	4	5	6	7	8	9	Easy to read
--------------	---	---	---	---	---	---	---	---	---	--------------

2.2 Highlighting on the screen is helpful :

Not at all	1	2	3	4	5	6	7	8	9	Very much
------------	---	---	---	---	---	---	---	---	---	-----------

2.3 Screen layout is helpful:

Never	1	2	3	4	5	6	7	8	9	Always
-------	---	---	---	---	---	---	---	---	---	--------

2.4 Sequence of the screens is :

Confusing	1	2	3	4	5	6	7	8	9	Clear
-----------	---	---	---	---	---	---	---	---	---	-------

Section 3 : Screen Proforma Terminology :

3.1 Terminology is:

Inconsistent | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Consistent

3.2 Message instruction is :

Inconsistent | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Consistent

3.3 Message instruction is :

Confusing | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Clear

3.4 The system keeps you informed :

Never | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Always

3.5 Error Messages is :

Unhelpful | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Helpful

Section 4 : Learning :

4.1 Learning to operate the system is :

Difficult | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Easy

4.2 Exploration by trial and error is:

Discouraging | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Encouraging

4.3 Tasks performed straight-forward :

Never | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Always

4.4 Help messages on screen is :

Confusing | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Clear

Section 5 : System capability :

5.1 System speed is :

Too slow | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Fast enough

5.2 System reliability is:

Unreliable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Reliable

5.3 Correcting mistakes is :

Difficult | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Easy

5.4 The user needs are taken into consideration :

Never | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Always

Section 6 : Do you have any other comments ? (if yes, please describe)

.....

.....

.....

.....

.....

Attached evaluation form

1. What level of your computer experience?
Not at all; rarely; intermediate; quite good; extensive
2. Have you had experience with computerised medical record?
Yes; No
3. Please describe your computer experience.
4. Does Electronic Eastman Pain Proforma (EPPP) sound to you like a good idea?
Strongly agree; Agree; Uncertain; Disagree; Strongly disagree
5. Do the questions in EEPP help you to lead to the diagnosis of facial pain?
Strongly agree; Agree; Uncertain; Disagree; Strongly disagree
Please explain why?
6. Could you find your way round EEPP easily?
Strongly agree; Agree; Uncertain; Disagree; Strongly disagree
7. How would you rate EPP overall?
0; 1; 2; 3; 4
8. How could EEPP be improved?

Thank you,
Premthip Chalidapongse,
Prof. Peter Hammond,
Prof. Malcolm Harris.

APPENDIX B

THE TRANSLATED DIAGNOSTIC RULES

This Appendix documents the rules translated from the hand-crafted decision trees for the diagnosis of CIFP presenting in Chapter 5.

B.1. Diagnostic Rules for Pain in the Frontal Region

The following 16 rules were translated from the hand-crafted decision tree illustrated in Figure 5-5 from Chapter 5. The diagnoses and related rules are also summarised here in Table B–1.

Rule 1	
IF	(complaint is pain) AND (site is frontal region) AND (quality of pain is short sharp/stabbing OR electric like) AND (provoked by touch OR facial movement) AND (numbness OR tingling OR burning) AND (history of vesicles OR facial palsy)
THEN	possible diagnosis is postherpetic neuralgia OR geniculate herpes (Ramsay Hunt Syndrome).
Rule 2	
IF	(complaint is pain) AND (site is frontal region) AND (quality of pain is short sharp/stabbing OR electric like) AND (provoked by touch OR facial movement) AND (numbness OR tingling OR burning) AND NOT (history of vesicles OR facial palsy) AND (MRI normal)
THEN	possible diagnosis is hybrid atypical facial pain and trigeminal neuralgia.
Rule 3	
IF	(complaint is pain) AND (site is frontal region) AND (quality of pain is short sharp/stabbing OR electric like) AND (provoked by touch OR facial movement) AND (numbness OR tingling OR burning) AND NOT (history of vesicles OR facial palsy) AND NOT (MRI normal)
THEN	possible diagnosis is multiple sclerosis OR intracranial tumour OR aneurysm.
Rule 4	
IF	(complaint is pain) AND (site is frontal region) AND (quality of pain is short sharp/stabbing OR electric like) AND (provoked by touch OR facial movement) AND NOT (numbness OR tingling OR burning)
THEN	possible diagnosis is trigeminal neuralgia.
Rule 5	
IF	(complaint is pain) AND (site is frontal region) AND

(quality of pain is short sharp/stabbing OR electric like) AND NOT
 (provoked by touch OR facial movement) AND
 (numbness OR tingling OR burning) AND
 (MRI normal)
 THEN possible diagnosis is atypical facial pain OR tension headache.

Rule 6

IF (complaint is pain) AND
 (site is frontal region) AND
 (quality of pain is short sharp/stabbing OR electric like) AND NOT
 (provoked by touch OR facial movement) AND
 (numbness OR tingling OR burning) AND NOT
 (MRI normal)
 THEN possible diagnosis is multiple sclerosis OR intracranial tumour OR aneurysm.

Rule 7

IF (complaint is pain) AND
 (site is frontal region) AND
 (quality of pain is short sharp/stabbing OR electric like) AND NOT
 (provoked by touch OR facial movement) AND NOT
 (numbness OR tingling OR burning)
 THEN possible diagnosis is atypical facial pain OR tension headache.

Rule 8

IF (complaint is pain) AND
 (site is frontal region) AND NOT
 (quality of pain is short sharp/stabbing OR electric like) AND
 (quality of pain is dull ache to severe throbbing) AND
 (nasal obstruction) AND
 (OM x-ray opaque frontal or sphenoidal sinus)
 THEN possible diagnosis is sinusitis OR frontal mucocoele.

Rule 9

IF (complaint is pain) AND
 (site is frontal region) AND NOT
 (quality of pain is short sharp/stabbing OR electric like) AND
 (quality of pain is dull ache to severe throbbing) AND
 (nasal obstruction) AND NOT
 (OM x-ray opaque frontal or sphenoidal sinus)
 THEN possible diagnosis is facial migrainous neuralgia.

Rule 10

IF (complaint is pain) AND
 (site is frontal region) AND NOT
 (quality of pain is short sharp/stabbing OR electric like) AND
 (quality of pain is dull ache to severe throbbing) AND NOT
 (nasal obstruction) AND
 (normal Blood Pressure) AND
 (OM. X-ray opaque frontal or sphenoid sinus)
 THEN possible diagnosis is sinusitis OR frontal mucocoele.

Rule 11

IF (complaint is pain) AND
 (site is frontal region) AND NOT
 (quality of pain is short sharp/stabbing OR electric like) AND
 (quality of pain is dull ache to severe throbbing) AND NOT
 (nasal obstruction) AND
 (normal Blood Pressure) AND NOT
 (OM. X-ray opaque frontal or sphenoid sinus) AND
 (numbness OR tingling OR burning) AND
 (normal MRI)
 THEN possible diagnosis is atypical facial pain OR tension headache.

Rule 12

IF (complaint is pain) AND
 (site is frontal region) AND NOT
 (quality of pain is short sharp/stabbing OR electric like) AND
 (quality of pain is dull ache to severe throbbing) AND NOT
 (nasal obstruction) AND

(normal Blood Pressure) AND NOT
 (OM. X-ray opaque frontal or sphenoid sinus) AND
 (numbness OR tingling OR burning) AND NOT
 (normal MRI)
 THEN possible diagnosis is intracranial tumour OR aneurysm.

Rule 13

IF (complaint is pain) AND
 (site is frontal region) AND NOT
 (quality of pain is short sharp/stabbing OR electric like) AND
 (quality of pain is dull ache to severe throbbing) AND NOT
 (nasal obstruction) AND
 (normal Blood Pressure) AND NOT
 (OM. X-ray opaque frontal or sphenoid sinus) AND NOT
 (numbness OR tingling OR burning) AND
 (photophobia OR nausea vomiting) AND
 (neck stiffness OR papilloedema)
 THEN possible diagnosis is intracranial hemorrhage OR space occupied lesion, confirm with MRI scan.

Rule 14

IF (complaint is pain) AND
 (site is frontal region) AND NOT
 (quality of pain is short sharp/stabbing OR electric like) AND
 (quality of pain is dull ache to severe throbbing) AND NOT
 (nasal obstruction) AND
 (normal Blood Pressure) AND NOT
 (OM. X-ray opaque frontal or sphenoid sinus) AND NOT
 (numbness OR tingling OR burning) AND
 (photophobia OR nausea vomiting) AND NOT
 (neck stiffness OR papilloedema)
 THEN possible diagnosis is migraine.

Rule 15

IF (complaint is pain) AND
 (site is frontal region) AND NOT
 (quality of pain is short sharp/stabbing OR electric like) AND
 (quality of pain is dull ache to severe throbbing) AND NOT
 (nasal obstruction) AND
 (normal Blood Pressure) AND NOT
 (OM. X-ray opaque frontal or sphenoid sinus) AND NOT
 (numbness OR tingling OR burning) AND NOT
 (photophobia OR nausea vomiting)
 THEN possible diagnosis is tension headache OR atypical facial pain.

Rule 16

IF (complaint is pain) AND
 (site is frontal region) AND NOT
 (quality of pain is short sharp/stabbing OR electric like) AND
 (quality of pain is dull ache to severe throbbing) AND NOT
 (nasal obstruction) AND NOT
 (normal Blood Pressure)
 THEN possible diagnosis is Hypertension.

Table B–1: Summary of the diagnoses and related rules translated from the hand-crafted decision tree of frontal region.

Diagnosis	Related Rules	No. of rules
1. Postherpetic neuralgia	R1	1
2. Geniculate herpes (Ramsay Hunt Syndrome)	R1	1
3. Hybrid Atypical Facial Pain and Trigeminal neuralgia	R2	1
4. Multiple sclerosis	R3, R6	2

Diagnosis	Related Rules	No. of rules
5. Intracranial Tumour	R3, R6, R12	3
6. Aneurysm	R3, R6, R12	3
7. Trigeminal Neuralgia	R4	1
8. Atypical facial pain	R5, R7, R11, R15	4
9. Tension headache	R5, R7, R11, R15	4
10. Sinusitis	R8, R10	2
11. Frontal mucocoele	R8, R10	2
12. Facial migrainous neuralgia	R9	1
13. Intracranial Hemorrhage	R13	1
14. Space Occupied Lesion	R13	1
15. Migraine	R14	1
16. Hypertension	R16	1

B.2. Diagnostic Rules for Pain in the TMJ and Parietotemporal Area

The following 21 rules were translated from the hand-crafted decision tree illustrated in Figure 5-6 from Chapter 5. The diagnoses and related rules are also summarised in Table B-2.

Rule 1

IF (Site is TMJ OR pre auricular OR temporoparietal) AND NOT
(Complaint is pain) AND
(Complaints is clicking / crepitus OR sticking / locking) AND
(X-ray TMJ is normal)
THEN Possible diagnosis is disc displacement with reduction

Rule 2

IF (Site is TMJ OR pre auricular OR temporoparietal) AND NOT
(Complaint is pain) AND
(Complaints is clicking / crepitus OR sticking / locking) AND NOT
(X-ray TMJ is normal)
THEN Possible diagnosis is osteoarthritis.

Rule 3

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND
(TMJ OR adjacent muscle tenderness) AND
(on examination limited mouth opening < 30 mm.) AND
(X-ray TMJ normal)
THEN Possible diagnosis is facial arthromyalgia.

Rule 4

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND
(TMJ OR adjacent muscle tenderness) AND
(on examination limited mouth opening < 30 mm.) AND NOT

THEN (X-ray TMJ normal) AND
(Autoimmune screening normal)
Possible diagnosis is osteoarthritis.

Rule 5

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND
(TMJ OR adjacent muscle tenderness) AND
(on examination limited mouth opening < 30 mm.) AND NOT
(X-ray TMJ normal) AND NOT
(Autoimmune screening normal)
THEN Possible diagnosis is rheumatoid arthritis.

Rule 6

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND
(TMJ OR adjacent muscle tenderness) AND NOT
(on examination limited mouth opening < 30 mm.) AND
(x-ray TMJ normal)
THEN Possible diagnosis is facial arthromyalgia.

Rule 7

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND
(TMJ OR adjacent muscle tenderness) AND NOT
(on examination limited mouth opening < 30 mm.) AND NOT
(x-ray TMJ normal) AND
(autoimmune screening normal)
THEN Possible diagnosis is osteoarthritis.

Rule 8

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND
(TMJ OR adjacent muscle tenderness) AND NOT
(on examination limited mouth opening < 30 mm.) AND NOT
(x-ray TMJ normal) AND NOT
(autoimmune screening normal)
THEN Possible diagnosis is rheumatoid arthritis.

Rule 9

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND NOT
(TMJ OR adjacent muscle tenderness) AND
(temporal region tender) AND
(ESP increased)
THEN Possible diagnosis is giant cell arteritis.

Rule 10

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND NOT
(TMJ OR adjacent muscle tenderness) AND

(temporal region tender) AND NOT
(ESP increased)
THEN Possible diagnosis is atypical facial pain.

Rule 11

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND NOT
(TMJ OR adjacent muscle tenderness) AND NOT
(temporal region tender)
THEN Possible diagnosis is atypical facial pain.

Rule 12

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND NOT
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND
(temporal region tender) AND
(ESR increased)
THEN Possible diagnosis is giant cell arteritis.

Rule 13

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND NOT
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND
(temporal region tender) AND NOT
(ESR increased)
THEN Possible diagnosis is atypical facial pain.

Rule 14

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND
(Pain is discomfort OR dull ache OR throbbing) AND NOT
(Provoked by opening OR yawning OR talking OR biting OR hard food OR emotional
tension OR fatigue) AND NOT
(temporal region tender)
THEN Possible diagnosis is atypical facial pain.

Rule 15

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND NOT
(Pain is discomfort OR dull ache OR throbbing) AND
(Pain is short sharp/stabbing OR electric like) AND
(Provoked by touch OR facial movement OR cold breeze) AND
(numbness OR tingling OR burning) AND
(history of vesicles OR facial palsy)
THEN Possible diagnosis is postherpetic neuralgia OR geniculate herpes (Ramsay Hunt
Syndrome).

Rule 16

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND NOT
(Pain is discomfort OR dull ache OR throbbing) AND
(Pain is short sharp/stabbing OR electric like) AND
(Provoked by touch OR facial movement OR cold breeze) AND
(numbness OR tingling OR burning) AND NOT
(history of vesicles OR facial palsy) AND
(MRI normal)
THEN Possible diagnosis is hybrid of atypical facial pain and trigeminal neuralgia.

Rule 17

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
(Complaint is pain) AND NOT
(Pain is discomfort OR dull ache OR throbbing) AND

(Pain is short sharp/stabbing OR electric like) AND
 (Provoked by touch OR facial movement OR cold breeze) AND
 (numbness OR tingling OR burning) AND NOT
 (history of vesicles OR facial palsy) AND NOT
 (MRI normal)
 THEN Possible diagnosis is intracranial tumour OR aneurysm OR nasopharyngeal ca. OR multiple sclerosis.

Rule 18

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
 (Complaint is pain) AND NOT
 (Pain is discomfort OR dull ache OR throbbing) AND
 (Pain is short sharp/stabbing OR electric like) AND
 (Provoked by touch OR facial movement OR cold breeze) AND NOT
 (numbness OR tingling OR burning)
 THEN Possible diagnosis is trigeminal neuralgia.

Rule 19

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
 (Complaint is pain) AND NOT
 (Pain is discomfort OR dull ache OR throbbing) AND
 (Pain is short sharp/stabbing OR electric like) AND
 (Provoked by touch OR facial movement OR cold breeze) AND NOT
 (provoked by opening OR yawning) AND
 (TMJ OR Muscle is tender) AND
 (x-ray TMJ is normal)
 THEN Possible diagnosis is facial arthromyalgia.

Rule 20

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
 (Complaint is pain) AND NOT
 (Pain is discomfort OR dull ache OR throbbing) AND
 (Pain is short sharp/stabbing OR electric like) AND
 (Provoked by touch OR facial movement OR cold breeze) AND NOT
 (provoked by opening OR yawning) AND
 (TMJ OR Muscle is tender) AND NOT
 (x-ray TMJ is normal) AND
 (autoimmune screening normal)
 THEN Possible diagnosis is osteoarthritis.

Rule 21

IF (Site is TMJ OR pre auricular OR temporoparietal) AND
 (Complaint is pain) AND NOT
 (Pain is discomfort OR dull ache OR throbbing) AND
 (Pain is short sharp/stabbing OR electric like) AND
 (Provoked by touch OR facial movement OR cold breeze) AND NOT
 (provoked by opening OR yawning) AND
 (TMJ OR Muscle is tender) AND NOT
 (x-ray TMJ is normal) AND NOT
 (autoimmune screening normal)
 THEN Possible diagnosis is rheumatoid arthritis.

Table B–2: Summary of the diagnoses and related rules translated from the hand-crafted decision tree of the TMJ and parietotemporal region.

Diagnosis	Rules	No. of rules
1. Disc displacement with reduction	R1	1
2. Osteoarthritis	R2	1
3. Facial arthromyalgia	R3, R6, R19	3
4. Osteoarthritis	R4, R7, R20	3
5. Rheumatoid arthritis	R5, R8, R21	3

Diagnosis	Rules	No. of rules
6. Giant cell arteritis	R9, R12	2
7. Atypical facial pain	R10, R11, R13, R14	4
8. Post herpetic neuralgia	R15	1
9. Geniculate herpes (Ramsay Hunt syndrome)	R15	1
10. Hybrid of AFP and trigeminal neuralgia	R16	1
11. Intracranial tumour	R17	1
12. Multiple sclerosis	R17	1
13. Aneurysm	R17	1
14. Nasopharyngeal carcinoma	R17	1
15. Trigeminal neuralgia	R18	1

B.3. Diagnostic Rules for Pain in the Maxilla Region

All 84 rules were translated from the hand-crafted decision trees illustrated in Figures 5-7 (SA, SB, SC, SD, DA, DB, DC, DD) from Chapter 5. The diagnoses and related rules are summarised in Table B–3.

Rules 1 – 7 are presented in Figure 5 – 7 SA

Rule 1

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND
(provoked by facial touch OR facial movement) AND
(numbness OR tingling OR burning) AND
(history of vesicles OR facial palsy)
THEN Possible diagnosis is postherpetic neuralgia OR geniculate herpes (Ramsay Hunt syndrome)

Rule 2

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND
(provoked by facial touch OR facial movement) AND
(numbness OR tingling OR burning) AND NOT
(history of vesicles OR facial palsy) AND
(MRI normal)
THEN Possible diagnosis is hybrid of atypical facial pain and trigeminal neuralgia.

Rule 3

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND
(provoked by facial touch OR facial movement) AND
(numbness OR tingling OR burning) AND NOT
(history of vesicles OR facial palsy) AND NOT
(MRI normal)
THEN Possible diagnosis is intracranial tumour OR nasopharyngeal carcinoma OR multiple sclerosis OR aneurysm.

Rule 4

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND
 (provoked by facial touch OR facial movement) AND NOT
 (numbness OR tingling OR burning)
 THEN Possible diagnosis is trigeminal neuralgia.
 CRITIQUE If under 40 years of age, MRI to exclude multiple sclerosis.

Rule 5

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND
 (provoked by opening OR yawning OR hard food) AND
 (TMJ is tender on palpation) AND
 (OPG x-ray shown normal TMJ)
 THEN possible diagnosis is facial arthromyalgia.

Rule 6

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND
 (provoked by opening OR yawning OR hard food) AND
 (TMJ is tender on palpation) AND NOT
 (OPG x-ray shown normal TMJ) AND
 (autoimmune screening is normal)
 THEN possible diagnosis is osteoarthritis.

Rule 7

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND
 (provoked by opening OR yawning OR hard food) AND
 (TMJ is tender on palpation) AND NOT
 (OPG x-ray shown normal TMJ) AND NOT
 (autoimmune screening is normal)
 THEN possible diagnosis is rheumatoid arthritis.

Rules 8 – 17 are presented in Figure 5 – 7 SB**Rule 8**

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (teeth is mobile AND pocketing)
 THEN possible diagnosis is reversible pulpitis/periodontitis (Endodontic-periodontal lesion).

Rule 9

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray is normal) AND
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is reversible pulpitis.

Rule 10

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray is normal) AND NOT
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is post restorative sensitivity.

Rule 11

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for secondary caries OR fracture positive)
 THEN possible diagnosis is reversible pulpitis OR cracked tooth.
 CRITIQUE Periapical x-ray should be ordered to check severity of the condition, although vertical fracture is difficult to detect from x-ray.

Rule 12

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for caries OR fracture positive) AND
 (periapical x-ray is normal) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 13

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for caries OR fracture positive) AND
 (periapical x-ray is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 14

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (restoration) AND
 (caries OR cavity)
 THEN possible diagnosis is reversible pulpitis.

Rule 15

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND
 (clinical fracture of crown)
 THEN possible diagnosis is post traumatic reversible pulpitis with acute apical periodontitis.
 CRITIQUE Periapical x-ray should be ordered to checked the severity of fracture on the tooth and
 periapical area. Vitality test should be performed as information for treatment planing
 and follow up.

Rule 16

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray is normal) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 17

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rules 18 – 31 are presented in Figure 5 – 7 SC

Rule 18

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND
 (restoration OR cavity OR caries) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 19

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT

(provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND
 (restoration OR cavity OR caries) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 20

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND NOT
 (restoration OR cavity OR caries) AND
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is post traumatic reversible pulpitis with chronic apical periodontitis.

Rule 21

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND NOT
 (restoration OR cavity OR caries) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 22

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND NOT
 (restoration OR cavity OR caries) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 23

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray shows normal periapical area) AND
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is reversible pulpitis.

Rule 24

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is Post restorative sensitivity.

Rule 25

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for secondary caries OR fracture is positive)
 THEN possible diagnosis is reversible pulpitis OR cracked tooth.

Rule 26

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND
 (periapical x-ray is normal) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 27

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND
 (periapical x-ray is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 28

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT

(provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND
 (caries)
 THEN possible diagnosis is reversible pulpitis.

Rule 29

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND NOT
 (caries) AND
 (exposed cervical dentine OR cavity from loss of filling) AND
 (brief sensitive to jet cold air and cold test)
 THEN possible diagnosis is exposed dentine sensitivity.

Rule 30

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND NOT
 (caries) AND
 (exposed cervical dentine OR cavity from loss of filling) AND NOT
 (brief sensitive to jet cold air and cold test) AND
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is reversible pulpitis.

Rule 31

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND NOT
 (caries) AND NOT
 (exposed cervical dentine OR cavity from loss of filling) AND
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is atypical odontalgia OR referred pain.

Rules 32 – 44 are presented in Figure 5 – 7 SD**Rule 32**

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray is normal)
 THEN possible diagnosis is post restorative sensitivity.

Rule 33

IF (complaint is pain) AND

(site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for leakage of restoration OR fracture tooth is positive)
 THEN possible diagnosis is reversible pulpitis from leakage of restoration OR cracked tooth.

Rule 34

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND
 (periapical x-ray shows normal periapical area) AND
 (thermal test or EPT test is normal) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 35

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND
 (periapical x-ray shows normal periapical area) AND
 (thermal test or EPT test is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 36

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (thermal test or EPT test is normal)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 37

IF (complaint is pain) AND
 (site is maxilla) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND NOT

THEN (periapical x-ray shows normal periapical area)
possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 38

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(restoration) AND
(traumatic occlusion OR history of trauma)
THEN possible diagnosis is acute apical periodontitis.

Rule 39

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(restoration) AND NOT
(traumatic occlusion OR history of trauma) AND
(periapical x-ray shows normal periapical area) AND
(thermal test or EPT is normal) AND
(biting test is positive)
THEN possible diagnosis is cracked tooth.

Rule 40

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(restoration) AND NOT
(traumatic occlusion OR history of trauma) AND
(periapical x-ray shows normal periapical area) AND
(thermal test or EPT is normal) AND NOT
(biting test is positive)
THEN possible diagnosis is atypical odontalgia.

Rule 41

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(restoration) AND NOT
(traumatic occlusion OR history of trauma) AND
(periapical x-ray shows normal periapical area) AND NOT
(thermal test or EPT is normal)
THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 42

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(restoration) AND NOT
(traumatic occlusion OR history of trauma) AND NOT

THEN (periapical x-ray shows normal periapical area)
possible diagnosis is pulp necrosis with acute apical periodontitis. The degree of progressive is more severe than rule 40.

Rule 43

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND
(periapical x-ray OR OPG x-ray is normal)
THEN possible diagnosis is referred pain OR atypical facial pain.

Rule 44

IF (complaint is pain) AND
(site is maxilla) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND NOT
(periapical x-ray OR OPG x-ray is normal)
THEN possible diagnosis is intraosseous pathology (benign or malignant).

Rules 45 – 53 are presented in Figure 5 – 7 DA**Rule 45**

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND
(tooth mobile AND pocketing)
THEN possible diagnosis is irreversible pulpitis periodontitis (endodontic-periodontal lesion).

Rule 46

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(tooth mobile AND pocketing) AND
(restoration OR caries OR cavity) AND
(periapical x-ray shows normal periapical area) AND
(exploration for pulp exposure is positive)
THEN possible diagnosis is irreversible pulpitis with acute apical periodontitis

Rule 47

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(tooth mobile AND pocketing) AND
(restoration OR caries OR cavity) AND
(periapical x-ray shows normal periapical area) AND NOT
(exploration for pulp exposure is positive) AND
(biting test is positive)
THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 48

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND

(dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 49

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration OR caries OR cavity) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is irreversible pulpitis with acute apical periodontitis.

Rule 50

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND
 (clinical crown fracture)
 THEN possible diagnosis is post traumatic irreversible pulpitis with acute apical periodontitis.
 CRITIQUE Periapical x-ray, visual examination for pulp exposure, vitality test should be conducted to establish information for treatment planing.

Rule 51

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical crown fracture) AND
 (periapical x-ray shows normal periapical area) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 52

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical crown fracture) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 53

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND

(provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical crown fracture) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is post traumatic irreversible pulpitis with acute apical periodontitis.

Rules 54 – 61 are presented in Figure 5 – 7 DB

Rule 54

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is irreversible pulpitis with apical periodontitis.

Rule 55

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 56

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 57

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is irreversible pulpitis with apical periodontitis.

Rule 58

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (restoration OR caries OR cavity) AND
 (clinical fracture of crown)
 THEN possible diagnosis is post traumatic irreversible pulpitis with apical periodontitis.

CRITIQUE Periapical x-ray, visual examination for pulp exposure, vitality test should be conducted to establish information for treatment planing.

Rule 59

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND NOT
(restoration OR caries OR cavity) AND NOT
(clinical fracture of crown) AND
(periapical x-ray shows normal periapical area) AND
(biting test is positive)
THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 60

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND NOT
(restoration OR caries OR cavity) AND NOT
(clinical fracture of crown) AND
(periapical x-ray shows normal periapical area) AND NOT
(biting test is positive)
THEN possible diagnosis is atypical odontalgia.

Rule 61

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND NOT
(restoration OR caries OR cavity) AND NOT
(clinical fracture of crown) AND NOT
(periapical x-ray shows normal periapical area)
THEN possible diagnosis is post traumatic irreversible pulpitis with apical periodontitis.

Rules 62 – 75 are presented in Figure 5 – 7 DC

Rule 62

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND
(tooth mobile AND pocketing)
THEN possible diagnosis is periodontitis.

Rule 63

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(tooth mobile AND pocketing) AND
(restoration) AND
(recent restoration)
THEN possible diagnosis is acute apical periodontitis. (Due to hyperocclusion)

Rule 64

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND

(dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for secondary caries OR fracture is positive)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis OR fracture of endo tooth.

Rule 65

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND
 (periapical x-ray shows normal periapical area) AND
 (thermal test or EPT test is normal)
 THEN possible diagnosis is atypical odontalgia.

Rule 66

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (thermal test or EPT test is normal)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 67

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND NOT
 (periapical x-ray shows normal periapical area) AND
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis. The degree of progress is more than rule 65.

Rule 68

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND
 (caries OR cavity) AND
 (exploration for pulp exposure is positive) AND NOT
 (thermal test or EPT test is normal)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 69

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND
 (clinical fracture of crown)
 THEN possible diagnosis is post traumatic pulp necrosis with acute apical periodontitis.
 CRITIQUE Periapical x-ray, visual examination for pulp exposure, vitality test should be conducted to establish information for treatment planing.

Rule 70

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (partially erupted molar with operculum inflammation)
 THEN possible diagnosis is pericoronitis.

Rule 71

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND
 (TMJ AND/OR muscle of mastication is tender)
 THEN possible diagnosis is facial arthromyalgia.

Rule 72

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND NOT
 (TMJ AND/OR muscle of mastication is tender) AND
 (enlarge tender of parotid gland)
 THEN possible diagnosis is sialolithiasis of parotid gland.

Rule 73

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT

(restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND NOT
 (TMJ AND/OR muscle of mastication is tender) AND
 (enlarge tender of parotid gland) AND
 (superficial temporal artery is palpated)
 THEN possible diagnosis is giant cell arteritis.
 CRITIQUE Confirmed by biopsy OR check for raised ESR.

Rule 74

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND NOT
 (TMJ AND/OR muscle of mastication is tender) AND
 (enlarge tender of parotid gland) AND NOT
 (superficial temporal artery is palpated) AND
 (OPG or periapical x-ray is normal)
 THEN possible diagnosis is atypical odontalgia OR atypical facial pain.

Rule 75

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND NOT
 (TMJ AND/OR muscle of mastication is tender) AND
 (enlarge tender of parotid gland) AND NOT
 (superficial temporal artery is palpated) AND NOT
 (OPG or periapical x-ray is normal)
 THEN possible diagnosis is intraosseous pathology (benign or malignant).

Rules 76 – 84 are presented in Figure 5 – 7 DD

Rule 76

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing OR hard food) AND
 (provoked by opening OR yawning)
 THEN possible diagnosis is facial arthromyalgia.

Rule 77

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing OR hard food) AND NOT
 (provoked by opening OR yawning) AND
 (provoked by bending head) AND
 (OM x-ray is normal)
 THEN possible diagnosis is atypical facial pain.

Rule 78

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by bending head) AND NOT
 (OM x-ray is normal) AND
 (OM x-ray shows fluid level)
 THEN possible diagnosis is maxillary sinusitis.

Rule 79

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by bending head) AND
 (nasal obstruction AND/OR epiphora) AND
 (OM x-ray is normal)
 THEN possible diagnosis is facial migrainous neuralgia.

Rule 80

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by bending head) AND
 (nasal obstruction AND/OR epiphora) AND NOT
 (OM x-ray is normal) AND
 (OM x-ray shows fluid level)
 THEN possible diagnosis is maxillary sinusitis.

Rule 81

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by bending head) AND
 (nasal obstruction AND/OR epiphora) AND NOT
 (OM x-ray is normal) AND NOT
 (OM x-ray shows fluid level) AND
 (OM x-ray shows diffuse OR opaque OR bone loss OR bone expansion)
 THEN possible diagnosis is odontogenic cyst/tumour OR carcinoma.
 CRITIQUE Confirm with CT scan.

Rule 82

IF (complaint is pain) AND
 (site is maxilla) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by bending head) AND NOT
 (nasal obstruction AND/OR epiphora) AND
 (OM x-ray is normal) AND
 (pain is nocturnal)

THEN possible diagnosis is facial migrainous neuralgia.

Rule 83

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by bending head) AND NOT
(nasal obstruction AND/OR epiphora) AND
(OM x-ray is normal) AND NOT
(OM x-ray shows diffuse OR opaque OR bone loss OR bone expansion)

THEN possible diagnosis is atypical facial pain.

Rule 84

IF (complaint is pain) AND
(site is maxilla) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by bending head) AND NOT
(nasal obstruction AND/OR epiphora) AND NOT
(OM x-ray is normal) AND
(pain is nocturnal)

THEN possible diagnosis is odontogenic cyst/tumour OR carcinoma.

CRITIQUE Confirm with CT scan.

Table B–3 : Summary of the diagnoses and related rules translated from the hand-crafted decision trees of the maxilla region.

Diagnosis	Rules	No. of rules
1. Post herpetic neuralgia	R1	1
2. Geniculate herpes (Ramsay Hunt Syndrome)	R1	1
3. Hybrid of AFP and TN	R2	1
4. Intracranial tumour	R3	1
5. Nasopharyngeal carcinoma	R3	1
6. Multiple sclerosis	R3	1
7. Aneurysm	R3	1
8. Trigeminal neuralgia	R4	1
9. Facial arthromyalgia	R5, R71, R76	3
10. Osteoarthritis	R6	1
11. Rheumatoid arthritis	R7	1
12. Reversible pulpitis/periodontitis (Endodontic-periodontal lesion)	R8	1
13. Reversible pulpitis.	R9, R11, R14, R23, R25, R28, R30, R33	8
14. Post restorative sensitivity	R10, R24, R32	3
15. Cracked tooth	R11, R12, R16, R18, R21, R25, R26, R33, R34, R39	10
16. Atypical odontalgia	R13, R17, R19, R22, R27, R31,	14

Diagnosis	Rules	No. of rules
	R35, R40, R48, R52, R56, R60, R65, R74	
17. Post traumatic reversible pulpitis with acute apical periodontitis	R15	1
18. Post traumatic reversible pulpitis with chronic acute apical periodontitis	R20	2
19. Exposed dentine sensitivity	R29	1
20. Referred pain	R31, R43	2
21. Pulp necrosis with acute apical periodontitis	R36, R37, R41, R42, R64, R66, R67, R68, R69	9
22. Acute apical periodontitis	R38	1
23. Intraosseous pathology	R44, R75	2
24. Atypical facial pain	R43, R74, R77, R83	4
25. Irreversible pulpitis/periodontitis (Endodontic-periodontal lesion)	R45	1
26. Irreversible pulpitis with acute apical periodontitis	R46	2
27. Cracked tooth with irreversible pulpitis	R47, R51, R55, R59	4
28. Post traumatic irreversible pulpitis with acute apical periodontitis	R50, R53	2
29. Irreversible pulpitis with chronic apical periodontitis	R54, R57	2
30. Post traumatic irreversible pulpitis with chronic apical periodontitis	R58, R61	2
31. Fracture of endodontic tooth with acute apical periodontitis	R64	1
32. Pericoronitis	R70	1
33. Sialolithiasis of parotid gland	R72	1
34. Giant cell arteritis	R73	1
35. Maxillary sinusitis	R78, R80	2
36. Facial migrainous neuralgia	R79, R82	2
37. Odontogenic cyst/tumour OR carcinoma	R81, R84	2

B.4. Diagnostic Rules for Pain in the Mandibular Region

All 78 rules were translated from the hand-crafted decision trees illustrated in Figures 5-8 (SA, SB, SC, SD, DA, DB, DC) from Chapter 5. The diagnoses and related rules are summarised in Table B-4.

Rules 1 – 17 are presented in Figure 5 – 8 SA

Rule 1

IF (complaint is pain) AND
(site is mandible) AND

(short sharp OR stabbing OR electric like pain) AND
 (provoked by facial touch OR facial movement) AND
 (numbness OR tingling OR burning) AND
 (history of vesicles OR facial palsy)
 THEN Possible diagnosis is postherpetic neuralgia OR geniculate herpes (Ramsay Hunt syndrome)

Rule 2

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp OR stabbing OR electric like pain) AND
 (provoked by facial touch OR facial movement) AND
 (numbness OR tingling OR burning) AND NOT
 (history of vesicles OR facial palsy) AND
 (MRI normal)
 THEN Possible diagnosis is hybrid of atypical facial pain and trigeminal neuralgia.

Rule 3

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp OR stabbing OR electric like pain) AND
 (provoked by facial touch OR facial movement) AND
 (numbness OR tingling OR burning) AND NOT
 (history of vesicles OR facial palsy) AND NOT
 (MRI normal)
 THEN Possible diagnosis is intracranial tumour OR nasopharyngeal carcinoma OR multiple sclerosis OR aneurysm.

Rule 4

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp OR stabbing OR electric like pain) AND
 (provoked by facial touch OR facial movement) AND NOT
 (numbness OR tingling OR burning)
 THEN Possible diagnosis is trigeminal neuralgia. If under 40 years of age, MRI to exclude multiple sclerosis.

Rule 5

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND
 (provoked by opening OR yawning OR hard food) AND
 (TMJ is tender on palpation) AND
 (OPG x-ray shown normal TMJ)
 THEN possible diagnosis is facial arthromyalgia.

Rule 6

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND
 (provoked by opening OR yawning OR hard food) AND
 (TMJ is tender on palpation) AND NOT
 (OPG x-ray shown normal TMJ) AND
 (autoimmune screening is normal)
 THEN possible diagnosis is osteoarthritis.

Rule 7

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND
 (provoked by opening OR yawning OR hard food) AND
 (TMJ is tender on palpation) AND NOT
 (OPG x-ray shown normal TMJ) AND NOT
 (autoimmune screening is normal)
 THEN possible diagnosis is rheumatoid arthritis.

Rule 8

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (teeth is mobile AND pocketing)
 THEN possible diagnosis is reversible pulpitis/periodontitis (Endodontic-periodontal lesion).

Rule 9

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth is mobile AND pocketing) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray is normal) AND
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is reversible pulpitis.

Rule 10

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth is mobile AND pocketing) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray is normal) AND NOT
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is post restorative sensitivity.

Rule 11

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth is mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for caries OR fracture positive)
 THEN possible diagnosis is reversible pulpitis OR cracked tooth.
 CRITIQUE Periapical x-ray should be ordered to check severity of the condition, although vertical fracture is difficult to detect from x-ray.

Rule 12

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth is mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT

(exploration for caries OR fracture positive) AND
(periapical x-ray is normal) AND
(biting test is positive)
THEN possible diagnosis is cracked tooth.

Rule 13

IF (complaint is pain) AND
(site is mandible) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(teeth is mobile AND pocketing) AND
(restoration) AND
(recent restoration) AND NOT
(exploration for caries OR fracture positive) AND
(periapical x-ray is normal) AND NOT
(biting test is positive)
THEN possible diagnosis is atypical odontalgia.

Rule 14

IF (complaint is pain) AND
(site is mandible) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(teeth is mobile AND pocketing) AND NOT
(restoration) AND
(caries OR cavity)
THEN possible diagnosis is reversible pulpitis.

Rule 15

IF (complaint is pain) AND
(site is mandible) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(teeth is mobile AND pocketing) AND NOT
(restoration) AND NOT
(caries OR cavity) AND
(clinical fracture of crown)
THEN possible diagnosis is post traumatic reversible pulpitis with acute apical peridontitis.
CRITIQUE Periapical x-ray should be ordered to checked the severity of fracture on the tooth and
periapical area. Vitality test should be performed as information for treatment planing
and follow up.

Rule 16

IF (complaint is pain) AND
(site is mandible) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(teeth is mobile AND pocketing) AND NOT
(restoration) AND NOT
(caries OR cavity) AND NOT
(clinical fracture of crown) AND
(periapical x-ray is normal) AND
(biting test is positive)
THEN possible diagnosis is cracked tooth.

Rule 17

IF (complaint is pain) AND

(site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth is mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rules 18 – 31 are presented in Figure 5 – 8 SB

Rule 18

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND
 (restoration OR cavity OR caries) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 19

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND
 (restoration OR cavity OR caries) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 20

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND NOT
 (restoration OR cavity OR caries) AND
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is post traumatic reversible pulpitis with apical periodontitis.

Rule 21

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND NOT

(restoration OR cavity OR caries) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 22

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND NOT
 (restoration OR cavity OR caries) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 23

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray shows normal periapical area) AND
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is reversible pulpitis.

Rule 24

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is post restorative sensitivity.

Rule 25

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for secondary caries OR fracture is positive)
 THEN possible diagnosis is reversible pulpitis OR cracked tooth.

Rule 26

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT

(provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary OR fracture is positive) AND
 (periapical x-ray is normal) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 27

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND NOT
 (periapical x-ray is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 28

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND
 (caries)
 THEN possible diagnosis is reversible pulpitis.

Rule 29

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND NOT
 (caries) AND
 (exposed cervical dentine OR cavity from loss of filling) AND
 (brief sensitive to jet cold air and cold test)
 THEN possible diagnosis is exposed dentine sensitivity.

Rule 30

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND NOT
 (caries) AND
 (exposed cervical dentine OR cavity from loss of filling) AND NOT
 (brief sensitive to jet cold air and cold test) AND

THEN (periapical x-ray shows normal periapical area)
possible diagnosis is reversible pulpitis.

Rule 31

IF (complaint is pain) AND
(site is mandible) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND NOT
(teeth tender to percussion) AND NOT
(restoration) AND NOT
(caries) AND NOT
(exposed cervical dentine OR cavity from loss of filling) AND
THEN (periapical x-ray shows normal periapical area)
possible diagnosis is atypical odontalgia OR referred pain.

Rules 32 – 44 are presented in Figure 5 – 8 SC**Rule 32**

IF (complaint is pain) AND
(site is mandible) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND
(restoration) AND
(recent restoration) AND
(periapical x-ray is normal)
THEN possible diagnosis is post restorative sensitivity.

Rule 33

IF (complaint is pain) AND
(site is mandible) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND
(restoration) AND NOT
(recent restoration) AND
(exploration for leakage of restoration OR fracture tooth is positive)
THEN possible diagnosis is reversible pulpitis from leakage of restoration OR cracked tooth.

Rule 34

IF (complaint is pain) AND
(site is mandible) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND
(restoration) AND NOT
(recent restoration) AND NOT
(exploration for leakage of restoration OR fracture tooth is positive) AND
(periapical x-ray shows normal periapical area) AND
(thermal test or EPT test is normal) AND
(biting test is positive)
THEN possible diagnosis is cracked tooth.

Rule 35

IF (complaint is pain) AND
(site is mandible) AND
(short sharp stabbing OR electric like pain) AND NOT
(provoked by facial touch OR facial movement) AND NOT
(provoked by opening OR yawning OR hard food) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND

(provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND
 (periapical x-ray shows normal periapical area) AND
 (thermal test or EPT test is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 36

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (thermal test or EPT test is normal)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 37

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 38

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (restoration) AND
 (traumatic occlusion OR history of trauma)
 THEN possible diagnosis is acute apical periodontitis.

Rule 39

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (restoration) AND NOT
 (traumatic occlusion OR history of trauma) AND
 (periapical x-ray shows normal periapical area) AND
 (thermal test or EPT is normal) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 40

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT

(provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (restoration) AND NOT
 (traumatic occlusion OR history of trauma) AND
 (periapical x-ray shows normal periapical area) AND
 (thermal test or EPT is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 41

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (restoration) AND NOT
 (traumatic occlusion OR history of trauma) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (thermal test or EPT is normal)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 42

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (restoration) AND NOT
 (traumatic occlusion OR history of trauma) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 43

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (OPG x-ray is normal)
 THEN possible diagnosis is referred pain OR atypical facial pain.

Rule 44

IF (complaint is pain) AND
 (site is mandible) AND
 (short sharp stabbing OR electric like pain) AND NOT
 (provoked by facial touch OR facial movement) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (OPG x-ray is normal)
 THEN possible diagnosis is intraosseous pathology (benign or malignant).

Rules 45 – 53 are presented in Fig. 5 –8 DA**Rule 45**

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND

THEN (mobile AND pocketing)
possible diagnosis is irreversible pulpitis/periodontitis (endodontic-periodontal lesion).

Rule 46

IF (complaint is pain) AND
(site is mandible) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(mobile AND pocketing) AND
(restoration OR caries OR cavity) AND
(periapical x-ray shows normal periapical area) AND
(exploration for pulp exposure is positive)
THEN possible diagnosis is irreversible pulpitis with acute apical periodontitis

Rule 47

IF (complaint is pain) AND
(site is mandible) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(mobile AND pocketing) AND
(restoration OR caries OR cavity) AND
(periapical x-ray shows normal periapical area) AND NOT
(exploration for pulp exposure is positive) AND
(biting test is positive)
THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 48

IF (complaint is pain) AND
(site is mandible) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(mobile AND pocketing) AND
(restoration OR caries OR cavity) AND
(periapical x-ray shows normal periapical area) AND NOT
(exploration pulp exposure is positive) AND NOT
(biting test is positive)
THEN possible diagnosis is atypical odontalgia.

Rule 49

IF (complaint is pain) AND
(site is mandible) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(mobile AND pocketing) AND
(restoration OR caries OR cavity) AND NOT
(periapical x-ray shows normal periapical area)
THEN possible diagnosis is irreversible pulpitis with acute apical periodontitis.

Rule 50

IF (complaint is pain) AND
(site is mandible) AND NOT
(short sharp stabbing OR electric like pain) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(mobile AND pocketing) AND NOT
(restoration OR caries OR cavity) AND
(clinical crown fracture)
THEN possible diagnosis is post traumatic irreversible pulpitis with acute apical periodontitis.
CRITIQUE Periapical x-ray, visual examination for pulp exposure, vitality test should be conducted to establish information for treatment planning.

Rule 51

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical crown fracture) AND
 (periapical x-ray shows normal periapical area) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 52

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical crown fracture) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 53

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical crown fracture) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is post traumatic irreversible pulpitis with acute apical periodontitis.

Rules 54 – 61 are presented in Figure 5 – 8 DB

Rule 54

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is irreversible pulpitis with apical periodontitis.

Rule 55

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 56

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 57

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is irreversible pulpitis with apical periodontitis.

Rule 58

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (restoration OR caries OR cavity) AND
 (clinical fracture of crown)
 THEN possible diagnosis is post traumatic irreversible pulpitis with apical periodontitis.
 CRITIQUE Periapical x-ray, visual examination for pulp exposure, vitality test should be conducted to establish information for treatment planing.

Rule 59

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 60

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 61

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND

(provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is post traumatic irreversible pulpitis with apical periodontitis.

Rules 62 – 78 are presented in Figure 5 – 8 DC

Rule 62

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (numb lip) AND NOT
 (OPG x-ray is normal)
 THEN possible diagnosis is malignant intraosseous tumour.

Rule 63

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND
 (tooth mobile AND pocketing)
 THEN possible diagnosis is periodontitis.

Rule 64

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND
 (recent restoration)
 THEN possible diagnosis is acute apical periodontitis.

Rule 65

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for secondary caries OR fracture is positive)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis OR fracture of endo tooth.

Rule 66

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT

(recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive)
 (periapical x-ray shows normal periapical area) AND
 (thermal test or EPT test is normal)
 THEN possible diagnosis is atypical odontalgia.

Rule 67

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive)
 (periapical x-ray shows normal periapical area) AND
 (thermal test or EPT test is normal)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 68

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND NOT
 (periapical x-ray shows normal periapical area) AND
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 69

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND
 (caries OR cavity) AND
 (exploration for pulp exposure is positive) AND
 (EPT test is negative)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 70

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND
 (clinical fracture of crown)
 THEN possible diagnosis is post traumatic pulp necrosis with acute apical periodontitis.
 CRITIQUE Periapical x-ray, visual examination for pulp exposure, vitality test should be conducted
 to establish information for treatment planning.

Rule 71

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (partially erupted molar with operculum inflammation)
 THEN possible diagnosis is pericoronitis.

Rule 72

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND
 (TMJ AND/OR muscle of mastication is tender)
 THEN possible diagnosis is facial arthromyalgia.

Rule 73

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND NOT
 (TMJ AND/OR muscle of mastication is tender) AND
 (superficial temporal artery is palpated)
 THEN possible diagnosis is giant cell arteritis.
 CRITIQUE Confirm with biopsy and check for raised ESR.

Rule 74

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND NOT
 (TMJ AND/OR muscle of mastication is tender) AND NOT
 (superficial temporal artery is palpated) AND
 (OPG OR periapical x-ray is normal)
 THEN possible diagnosis is atypical odontalgia OR atypical facial pain.

Rule 75

IF (complaint is pain) AND
 (site is mandible) AND NOT

(short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (numb lip) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND NOT
 (TMJ AND/OR muscle of mastication is tender) AND NOT
 (superficial temporal artery is palpated) AND NOT
 (OPG OR periapical x-ray is normal)
 THEN possible diagnosis is chronic osteomyelitis OR infected cyst OR benign intraosseous tumour.

Rule 76

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (provoked by opening OR yawning OR hard food)
 THEN possible diagnosis is facial arthromyalgia.

Rule 77

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (provoked by opening OR yawning OR hard food) AND
 (OPG x-ray is normal)
 THEN possible diagnosis is atypical facial pain.

Rule 78

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (provoked by opening OR yawning OR hard food) AND NOT
 (OPG x-ray is normal)
 THEN possible diagnosis is chronic osteomyelitis OR infected cyst OR benign intraosseous tumour.

Table B-4: Summary of the diagnoses and related rules translated from the hand-crafted decision trees of the mandibular region.

Diagnosis	Rules	No. of rules
1. Post herpetic neuralgia	R1	1
2. Geniculate herpes (Ramsay Hunt Syndrome)	R1	1
3. Hybrid of AFP and TN	R2	1
4. Intracranial tumour	R3	1
5. Nasopharyngeal carcinoma	R3	1
6. Multiple sclerosis	R3	1
7. Trigeminal neuralgia	R4	1
8. Facial arthromyalgia	R5, R72, R76	3

Diagnosis	Rules	No. of rules
9. Osteoarthritis	R6	1
10. Rheumatoid arthritis	R7	1
11. Reversible pulpitis/periodontitis (Endodontic-periodontal lesion)	R8	1
12. Reversible pulpitis.	R9, R11, R14, R23, R25, R28, R30, R33	8
13. Post restorative sensitivity	R10, R24, R32	3
14. Cracked tooth	R11, R12, R16, R18, R21, R25, R26, R33, R34, R39	10
15. Atypical odontalgia	R13, R17, R19, R22, R27, R31, R35, R40, R48, R52, R56, R60, R67, R74	14
16. Post traumatic reversible pulpitis with acute apical periodontitis	R15	1
17. Post traumatic reversible pulpitis with chronic apical periodontitis	R20	1
18. Exposed dentine sensitivity	R29	1
19. Referred pain	R31, R43	2
20. Pulp necrosis with acute apical periodontitis	R36, R37, R41, R42	4
21. Acute apical periodontitis	R38, R64	2
22. Atypical facial pain	R42, R74, R77	3
23. Intraosseous pathology	R44	1
24. Irreversible pulpitis/periodontitis (Endodontic-periodontal lesion)	R45	1
25. Irreversible pulpitis with acute apical periodontitis	R46, R49	2
26. Cracked tooth with irreversible pulpitis	R47, R51, R55, R59	4
27. Post traumatic irreversible pulpitis with acute apical periodontitis	R50, R53	2
28. Irreversible pulpitis with chronic apical periodontitis	R54, R57	2
29. Post traumatic irreversible pulpitis with chronic apical periodontitis	R58, R61	2
30. Malignant intraosseous tumour	R62	1
31. Periodontitis	R63	1
32. Pulp necrosis with acute apical periodontitis	R65, R67, R68, R69	4
33. Fracture of endodontic tooth with acute apical periodontitis	R65	1
34. Post traumatic pulp necrosis with acute apical periodontitis	R70	1
35. Pericoronitis	R71	1
36. Giant cell arteritis	R73	1

Diagnosis	Rules	No. of rules
37. Chronic osteomyelitis	R75, R78	2
38. Infected cyst	R75, R78	2
39. benign intraosseous tumour	R75, R78	2

B.5. Diagnostic Rules for Pain in the Teeth and Alveolar Region

The following 67 rules were translated from the hand-crafted decision trees illustrated in Figures 5-9 (SA, SB, SC, DA, DB, DC) from Chapter 5. The diagnoses and related rules are summarised in Table B-5.

Rules 1 – 10 are presented in Fig. 5 – 9 SA

Rule 1

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND
(teeth are mobile AND pocketing)
THEN possible diagnosis is reversible pulpitis/periodontitis (Endodontal-periodontic lesion).

Rule 2

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(teeth are mobile AND pocketing) AND
(restoration) AND
(recent restoration) AND
(periapical x-ray is normal) AND
(exploration for pulp exposure is positive)
THEN possible diagnosis is reversible pulpitis.

Rule 3

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(teeth are mobile AND pocketing) AND
(restoration) AND
(recent restoration) AND
(periapical x-ray is normal) AND NOT
(exploration for pulp exposure is positive)
THEN possible diagnosis is post restorative sensitivity.

Rule 4

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(teeth are mobile AND pocketing) AND
(restoration) AND NOT
(recent restoration) AND
(exploration for secondary caries OR fracture positive)
THEN possible diagnosis is reversible pulpitis OR cracked tooth.

CRITIQUE Periapical x-ray should be ordered to check severity of the condition, although vertical fracture is difficult to detect from x-ray.

Rule 5

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth are mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for caries OR fracture positive) AND
 (periapical x-ray is normal) AND
 (biting test is positive)
THEN possible diagnosis is cracked tooth.

Rule 6

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth are mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for caries OR fracture positive) AND
 (periapical x-ray is normal) AND NOT
 (biting test is positive)
THEN possible diagnosis is atypical odontalgia.

Rule 7

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth are mobile AND pocketing) AND NOT
 (restoration) AND
 (caries OR cavity)
THEN possible diagnosis is reversible pulpitis.

Rule 8

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth are mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND
 (clinical fracture of crown)
THEN possible diagnosis is post traumatic reversible pulpitis with acute apical peridontitis.
CRITIQUE Periapical x-ray should be ordered to checked the severity of fracture on the tooth and periapical area. Vitality test should be performed as information for treatment planing and follow up.

Rule 9

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (teeth are mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray is normal) AND
 (biting test is positive)

THEN possible diagnosis is cracked tooth.

Rule 10

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(teeth are mobile AND pocketing) AND NOT
(restoration) AND NOT
(caries OR cavity) AND NOT
(clinical fracture of crown) AND
(periapical x-ray is normal) AND NOT
(biting test is positive)

THEN possible diagnosis is atypical odontalgia.

Rules 11 – 24 are presented in Fig. 5 – 9 SB

Rule 11

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND
(teeth tender to percussion) AND
(restoration OR cavity OR caries) AND
(periapical x-ray shows normal periapical area) AND NOT
(exploration for pulp exposure is positive) AND
(biting test is positive)

THEN possible diagnosis is cracked tooth.

Rule 12

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND
(teeth tender to percussion) AND
(restoration OR cavity OR caries) AND
(periapical x-ray shows normal periapical area) AND NOT
(exploration for pulp exposure is positive) AND NOT
(biting test is positive)

THEN possible diagnosis is atypical odontalgia.

Rule 13

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND
(teeth tender to percussion) AND NOT
(restoration OR cavity OR caries) AND
(clinical fracture of crown) AND
(periapical x-ray shows normal periapical area)

THEN possible diagnosis is post traumatic reversible pulpitis with apical periodontitis.

Rule 14

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND
(teeth tender to percussion) AND NOT
(restoration OR cavity OR caries) AND NOT
(clinical fracture of crown) AND
(periapical x-ray shows normal periapical area) AND
(biting test is positive)

THEN possible diagnosis is cracked tooth.

Rule 15

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (teeth tender to percussion) AND NOT
 (restoration OR cavity OR caries) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 16

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray shows normal periapical area) AND
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is reversible pulpitis.

Rule 17

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is Post restorative sensitivity.

Rule 18

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for secondary caries OR fracture is positive)
 THEN possible diagnosis is reversible pulpitis OR cracked tooth.

Rule 19

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND
 (periapical x-ray is normal) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 20

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND

(short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND
 (periapical x-ray is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 21

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND
 (caries)
 THEN possible diagnosis is reversible pulpitis.

Rule 22

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND NOT
 (caries) AND
 (exposed cervical dentine OR cavity from loss of filling) AND
 (brief sensitive to jet cold air and cold test)
 THEN possible diagnosis is exposed dentine sensitivity.

Rule 23

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND NOT
 (caries) AND
 (exposed cervical dentine OR cavity from loss of filling) AND NOT
 (brief sensitive to jet cold air and cold test) AND
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is reversible pulpitis.

Rule 24

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (teeth tender to percussion) AND NOT
 (restoration) AND NOT
 (caries) AND NOT
 (exposed cervical dentine OR cavity from loss of filling) AND
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is atypical odontalgia OR referred pain.

Rules 25 – 37 are presented in Fig. 5 – 9 SC

Rule 25

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND

(short sharp stabbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND
 (recent restoration) AND
 (periapical x-ray is normal)
 THEN possible diagnosis is post restorative sensitivity.

Rule 26

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for leakage of restoration OR fracture tooth is positive)
 THEN possible diagnosis is reversible pulpitis from leakage of restoration OR cracked tooth.

Rule 27

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND
 (periapical x-ray shows normal periapical area) AND
 (EPT test is normal) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth.

Rule 28

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND
 (periapical x-ray shows normal periapical area) AND
 (EPT test is normal) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 29

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (EPT test is normal)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 30

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND
 (short sharp stabbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for leakage of restoration OR fracture tooth is positive) AND NOT

THEN (periapical x-ray shows normal periapical area)
possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 31

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(restoration) AND
(traumatic occlusion OR history of trauma)
THEN possible diagnosis is acute apical periodontitis.

Rule 32

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(restoration) AND NOT
(traumatic occlusion OR history of trauma) AND
(periapical x-ray shows normal periapical area) AND
(EPT is normal) AND
(biting test is positive)
THEN possible diagnosis is cracked tooth.

Rule 33

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(restoration) AND NOT
(traumatic occlusion OR history of trauma) AND
(periapical x-ray shows normal periapical area) AND
(EPT is normal) AND NOT
(biting test is positive)
THEN possible diagnosis is atypical odontalgia.

Rule 34

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(restoration) AND NOT
(traumatic occlusion OR history of trauma) AND
(periapical x-ray shows normal periapical area) AND NOT
(EPT is normal)
THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 35

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND NOT
(provoked by biting OR chewing) AND NOT
(restoration) AND NOT
(traumatic occlusion OR history of trauma) AND NOT
(periapical x-ray shows normal periapical area)
THEN possible diagnosis is pulp necrosis with acute apical periodontitis. The degree of
progressive is more severe than rule 40.

Rule 36

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND
(periapical x-ray OR OPG x-ray is normal)

THEN possible diagnosis is referred pain.

Rule 37

IF (complaint is pain) AND
(site is teeth OR alveolus) AND
(short sharp stabbing) AND NOT
(provoked by hot OR cold OR sweet food / drink) AND NOT
(provoked by biting OR chewing) AND NOT
(periapical x-ray OR OPG x-ray is normal)
THEN possible diagnosis is intraosseous pathology (benign or malignant).

Rules 38 – 46 are presented in Fig. 5 – 9 DA

Rule 38

IF (complaint is pain) AND
(site is teeth OR alveolus) AND NOT
(short sharp stabbing) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND
(tooth mobile AND pocketing)
THEN possible diagnosis is irreversible pulpitis periodontitis (endodontic-periodontal lesion).

Rule 39

IF (complaint is pain) AND
(site is teeth OR alveolus) AND NOT
(short sharp stabbing) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(tooth mobile AND pocketing) AND
(restoration OR caries OR cavity) AND
(periapical x-ray shows normal periapical area) AND
(exploration for pulp exposure is positive)
THEN possible diagnosis is irreversible pulpitis with acute apical periodontitis

Rule 40

IF (complaint is pain) AND
(site is teeth OR alveolus) AND NOT
(short sharp stabbing) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(tooth mobile AND pocketing) AND
(restoration OR caries OR cavity) AND
(periapical x-ray shows normal periapical area) AND NOT
(exploration for pulp exposure is positive) AND
(biting test is positive)
THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 41

IF (complaint is pain) AND
(site is teeth OR alveolus) AND NOT
(short sharp stabbing) AND
(dull ache OR throbbing) AND
(provoked by hot OR cold OR sweet food / drink) AND
(provoked by biting OR chewing) AND NOT
(tooth mobile AND pocketing) AND
(restoration OR caries OR cavity) AND
(periapical x-ray shows normal periapical area) AND NOT
(exploration for pulp exposure is positive) AND NOT
(biting test is positive)
THEN possible diagnosis is atypical odontalgia.

Rule 42

IF (complaint is pain) AND
(site is teeth OR alveolus) AND NOT
(short sharp stabbing) AND
(dull ache OR throbbing) AND

(provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration OR caries OR cavity) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is irreversible pulpitis with acute apical periodontitis.

Rule 43

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND
 (clinical crown fracture)
 THEN possible diagnosis is post traumatic irreversible pulpitis with acute apical periodontitis.
 CRITIQUE Periapical x-ray, visual examination for pulp exposure, vitality test should be conducted to establish information for treatment planing.

Rule 44

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical crown fracture) AND
 (periapical x-ray shows normal periapical area) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 45

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical crown fracture) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 46

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical crown fracture) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is post traumatic irreversible pulpitis with acute apical periodontitis.

Rules 47 –54 are presented in Figure 5 – 9 DB

Rule 47

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND

(provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND
 (exploration for pulp exposure is positive)
 THEN possible diagnosis is irreversible pulpitis with apical periodontitis.

Rule 48

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 49

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (exploration for pulp exposure is positive) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 50

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (restoration OR caries OR cavity) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is irreversible pulpitis with apical periodontitis.

Rule 51

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (restoration OR caries OR cavity) AND
 (clinical fracture of crown)
 THEN possible diagnosis is post traumatic irreversible pulpitis with apical periodontitis.
 CRITIQUE Periapical x-ray, visual examination for pulp exposure, vitality test should be conducted to establish information for treatment planing.

Rule 52

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area) AND
 (biting test is positive)
 THEN possible diagnosis is cracked tooth with irreversible pulpitis.

Rule 53

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (biting test is positive)
 THEN possible diagnosis is atypical odontalgia.

Rule 54

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (restoration OR caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (periapical x-ray shows normal periapical area)
 THEN possible diagnosis is post traumatic irreversible pulpitis with apical periodontitis.

Rules 55 – 67 are presented in Fig. 5 – 9 DC

Rule 55

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND
 (tooth mobile AND pocketing)
 THEN possible diagnosis is periodontitis.

Rule 56

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND
 (recent restoration)
 THEN possible diagnosis is acute apical periodontitis. (Due to hyperocclusion)

Rule 57

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing OR electric like pain) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND
 (exploration for secondary caries OR fracture is positive)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis OR fracture of endo tooth.

Rule 58

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT

(provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND
 (periapical x-ray shows normal periapical area) AND
 (thermal test or EPT test is normal)
 THEN possible diagnosis is atypical odontalgia.

Rule 59

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND
 (periapical x-ray shows normal periapical area) AND NOT
 (thermal test or EPT test is normal)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 60

IF (complaint is pain) AND
 (site is mandible) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND
 (restoration) AND NOT
 (recent restoration) AND NOT
 (exploration for secondary caries OR fracture is positive) AND NOT
 (periapical x-ray shows normal periapical area) AND
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis. The degree of
 progress is more than rule 65.

Rule 61

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND
 (caries OR cavity) AND
 (exploration for pulp exposure is positive) AND NOT
 (thermal test or EPT test is normal)
 THEN possible diagnosis is pulp necrosis with acute apical periodontitis.

Rule 62

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND
 (clinical fracture of crown)
 THEN possible diagnosis is post traumatic pulp necrosis with acute apical periodontitis.
 CRITIQUE Periapical x-ray, visual examination for pulp exposure, vitality test should be conducted
 to establish information for treatment planing.

Rule 63

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND
 (partially erupted molar with operculum inflammation)
 THEN possible diagnosis is pericoronitis.

Rule 64

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND
 (periapical x-ray OR OPG x-ray is normal)
 THEN possible diagnosis is atypical odontalgia OR atypical facial pain.

Rule 65

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND
 (provoked by biting OR chewing) AND NOT
 (tooth mobile AND pocketing) AND NOT
 (restoration) AND NOT
 (caries OR cavity) AND NOT
 (clinical fracture of crown) AND NOT
 (partially erupted molar with operculum inflammation) AND NOT
 (periapical x-ray OR OPG x-ray is normal)
 THEN possible diagnosis is intraosseous pathology OR post traumatic pulp necrosis with acute apical periodontitis.

Rule 66

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND
 (periapical x-ray OR OPG x-ray is normal)
 THEN possible diagnosis is referred pain OR atypical odontalgia.

Rule 67

IF (complaint is pain) AND
 (site is teeth OR alveolus) AND NOT
 (short sharp stabbing) AND
 (dull ache OR throbbing) AND NOT
 (provoked by hot OR cold OR sweet food / drink) AND NOT
 (provoked by biting OR chewing) AND NOT
 (periapical x-ray OR OPG x-ray is normal)
 THEN possible diagnosis is chronic osteomyelitis OR infected cyst OR benign intraosseous tumour.

Table B–5: Summary of the diagnoses and related rules translated from the hand-crafted decision trees of the teeth and alveolar region.

Diagnosis	Rules	No. of rules
1. Reversible pulpitis/periodontitis (Endodontic-periodontal lesion)	R1	1
2. Reversible pulpitis.	R2, R4, R7, R16, R18, R21, R23, R26	8
3. Post restorative sensitivity	R3, R17, R25	3
4. Cracked tooth	R4, R5, R9, R11, R14, R18, R19, R26, R27, R32	10
5. Atypical odontalgia	R6, R10, R12, R15, R20, R24, R28, R33, R41, R45, R49, R53, R58, R64	14
6. Post traumatic reversible pulpitis with acute apical periodontitis	R8	1
7. Post traumatic reversible pulpitis with chronic apical periodontitis	R13	1
8. Exposed dentine sensitivity	R22	2
9. Referred pain	R24, R36	1
10. Pulp necrosis with acute apical periodontitis	R29, R30, R34, R35, R57, R59, R60, R61	8
11. Acute apical periodontitis	R31, R56	2
12. Intraosseous pathology	R37, R65	2
13. Irreversible pulpitis/periodontitis (Endodontic-periodontal lesion)	R38	1
14. Irreversible pulpitis with acute apical periodontitis	R39, R42	2
15. Cracked tooth with irreversible pulpitis	R40, R44, R48, R52	4
16. Post traumatic irreversible pulpitis with acute apical periodontitis	R43, R46	2
17. Irreversible pulpitis with chronic apical periodontitis	R47, R50	2
18. Post traumatic irreversible pulpitis with chronic apical periodontitis	R51, R54	2
19. Periodontitis	R55	1
20. Fracture of endodontic tooth with acute apical periodontitis	R57	1
21. Post traumatic pulp necrosis with acute apical periodontitis	R62, R65	2
22. Pericoronitis	R63	1
23. Atypical facial pain	R64	1

B.6. Diagnostic Rules for Pain in the Oral Mucosa Region

The following 11 rules were translated from the hand-crafted decision trees illustrated in Figures 5-10 (SA, SB) from Chapter 5. The diagnoses and related rules are summarised in Table B–6.

Rules 1 – 6 are presented in Figure 5-10 A

Rule 1

IF (complaint is pain OR disturbance of oral sensation) AND
(site is oral mucosa) AND
(quality of pain is burning) AND
(relieved by food and drink) AND
(screening for iron OR vit B12 OR folic acid is deficient)
THEN possible diagnosis is deficiency anaemia AND/OR acute candidiasis. Confirmed with
salivary candida count.

Rule 2

IF (complaint is pain OR disturbance of oral sensation) AND
(site is oral mucosa) AND
(quality of pain is burning) AND
(relieved by food and drink) AND NOT
(screening for iron OR vit B12 OR folic acid is deficient)
THEN possible diagnosis is oral dyesthesia.

Rule 3

IF (complaint is pain OR disturbance of oral sensation) AND
(site is oral mucosa) AND
(quality of pain is burning) AND NOT
(relieved by food and drink) AND
(clinical oral examination normal) AND
(screening for iron OR vit B12 OR folic acid is deficient)
THEN possible diagnosis is deficiency anaemia AND/OR acute candidiasis. Confirmed with
salivary candida count.

Rule 4

IF (complaint is pain OR disturbance of oral sensation) AND
(site is oral mucosa) AND
(quality of pain is burning) AND NOT
(relieved by food and drink) AND
(clinical oral examination normal) AND NOT
(screening for iron OR vit B12 OR folic acid is deficient)
THEN possible diagnosis is oral dyesthesia.

Rule 5

IF (complaint is pain OR disturbance of oral sensation) AND
(site is oral mucosa) AND
(quality of pain is burning) AND NOT
(relieved by food and drink) AND NOT
(clinical oral examination normal) AND
(screening for iron OR vit B12 OR folic acid is deficient)
THEN possible diagnosis is deficiency anaemia AND/OR acute candidiasis. Confirmed with
salivary candida count.

Rule 6

IF (complaint is pain OR disturbance of oral sensation) AND
(site is oral mucosa) AND
(quality of pain is burning) AND NOT
(relieved by food and drink) AND NOT
(clinical oral examination normal) AND NOT
(screening for iron OR vit B12 OR folic acid is deficient)
THEN possible diagnosis is mucosal lesion OR dysplasia. Required biopsy to exclude
carcinoma.

Rules 7 –11 are presented in Figure 5-10 B

Rule 7

IF (complaint is pain OR disturbance of oral sensation) AND
 (site is oral mucosa) AND NOT
 (quality of pain is burning) AND
 (stabbing shooting pain) AND
 (provoked by acidic/spicy food OR chewing) AND
 (erosion OR ulceration)
 THEN possible diagnosis is Aphthous ulcer OR mucosal lesion. Require biopsy to exclude carcinoma.

Rule 8

IF (complaint is pain OR disturbance of oral sensation) AND
 (site is oral mucosa) AND NOT
 (quality of pain is burning) AND
 (stabbing shooting pain) AND
 (provoked by acidic/spicy food OR chewing) AND NOT
 (erosion OR ulceration) AND
 (numbness OR tingling)
 THEN possible diagnosis is neuralgia secondary to neoplasm. Confirmed with MRI.

Rule 9

IF (complaint is pain OR disturbance of oral sensation) AND
 (site is oral mucosa) AND NOT
 (quality of pain is burning) AND
 (stabbing shooting pain) AND
 (provoked by acidic/spicy food OR chewing) AND NOT
 (erosion or ulceration) AND NOT
 (numbness OR tingling)
 THEN possible diagnosis is trigeminal neuralgia OR glossopharyngeal neuralgia.

Rule 10

IF (complaint is pain OR disturbance of oral sensation) AND
 (site is oral mucosa) AND NOT
 (quality of pain is burning) AND
 (stabbing shooting pain) AND NOT
 (provoked by acidic/spicy food OR chewing) AND
 (numbness OR tingling)
 THEN possible diagnosis is neuralgia secondary to neoplasm. Confirmed with MRI.

Rule 11

IF (complaint is pain OR disturbance of oral sensation) AND
 (site is oral mucosa) AND NOT
 (quality of pain is burning) AND
 (stabbing shooting pain) AND NOT
 (provoked by acidic/spicy food OR chewing) AND
 (numbness OR tingling)
 THEN possible diagnosis is trigeminal neuralgia OR glossopharyngeal neuralgia.

Table B–6: Summary of the diagnoses and related rules translated from the hand-crafted decision trees of the oral mucosa region.

Diagnosis	Rules	No. of rules
1.Deficiency anaemia	R1, R3, R5	3
2.Acute candidiasis	R1, R3, R5	3
3.Oral dysaesthesia	R2, R4	2
4.Mucosal lesion	R6, R7	2
5.Dysplasia	R7	1
6.Aphthous ulcer	R6	1
7.Neuralgia secondary to neoplasm	R8, R10	2

Diagnosis	Rules	No. of rules
8.Trigeminal neuralgia	R9, R11	2
9.Glossopharyngeal neuralgia	R9, R11	2

APPENDIX C

THE THEORY AND ILLUSTRATIONS

Appendix C serves as a supplement to Chapter 6. The appendix consists of: (1) the decision tree construction theory and illustration, (2) the standard format for data preparation in data mining, (3) the Clementine software description, (4) the detail of cross-validation method, (5) the scoring method for ranking attributes in induced decision trees, (6) the statistics method for quantitative analysis of the performance of induced decision trees, and (4) the other resulting induced decision trees with high diagnostic accuracy.

C.1. Decision Tree Construction Theory and Illustration

Decision tree can be constructed by using the concept in communication theory. In this theory, the information is expressed in mathematical terms as “information is the negative value of the logarithm base 2 of the probability of occurrence” which can be written as;

$$I = -\log_2 p, \text{ where } 0 \leq p \leq 1.$$

where I is the information content in bits (binary digits, the bit being by definition the smallest unit of information)

For example, if there are 2 equally probable messages, the information conveyed by any one of them is $-\log_2 (1/2)$ or 1 bit. The implication this law is that we must strive to have a maximal information content at the sender's site, and we should take all possible measures to keep the disturbance in the transmission process as low as possible.

We use the ID3 algorithm as a model for studying decision tree construction. The following example of “play tennis” is taken from Mitchell (1997) and Quinlan (1993) to illustrate how decision trees are constructed.

Given a collection S , containing positive (e.g. “Play”) and negative (e.g. “Don’t Play”) instances of some classification (e.g. “Play Tennis”), the average amount of information to identify the class of “Play” and “Don’t Play” is:

$$\text{Info}(S) \equiv -\left(\frac{p}{p+n}\right)\left(\log_2\left(\frac{p}{p+n}\right)\right) - \left(\frac{n}{p+n}\right)\left(\log_2\left(\frac{n}{p+n}\right)\right)$$

where $\frac{p}{p+n}$ is the proportion of positive instances,

$\frac{n}{p+n}$ is the proportion of negative instances

A more general form of information which conveyed, if the attribute can take more than two different values is

$$\text{Info}(S) \equiv \sum_{i=1}^c -p_i \log_2 p_i$$

where p_i is the proportion of S belonging to class i

c is possible values of attribute

The information gain is the expected reduction in information conveyed caused by partitioning the training instances according to this attribute. The information gain of attribute A can be written as the value $\text{Gain}(S, A)$ relative to a collection of examples S as follows:

$$\text{Gain}(S, A) \equiv \text{Entropy}(S) - \sum_{v \in \text{Values}(A)} \frac{|S_v|}{|S|} \text{Entropy} |S_v|$$

where $\text{Values}(A)$ is the set of all possible values for attributes A ,

S_v is the subset of S for which attribute A has value v ,

$\text{Entropy} |S_v|$ is the sum of the entropies of each subset S_v , weighted by

the fraction of examples $\frac{|S_v|}{|S|}$ that belong to S_v

Therefore, $\text{Gain}(S, A)$ is the expected reduction in entropy caused by knowing the value of attribute A .

We illustrate how a decision tree is constructed using the information gain criterion, with a training data set for deciding whether to play tennis modified from Quinlan 1993 (Table C–1).

Table C-1: A training data set of instances of the decision for play tennis.

Case	Outlook	Temperature	Humidity	Wind	Decision
C1	sunny	hot	high	weak	don't play
C2	sunny	hot	high	strong	don't play
C3	sunny	mild	high	weak	don't play
C4	sunny	cool	normal	weak	play
C5	sunny	mild	normal	strong	play
C6	overcast	cool	normal	strong	play
C7	overcast	hot	high	weak	play
C8	overcast	mild	high	strong	play
C9	overcast	hot	normal	weak	play
C10	rain	cool	normal	strong	don't play
C11	rain	mild	high	strong	don't play
C12	rain	mild	high	weak	play
C13	rain	cool	normal	weak	play
C14	rain	mild	normal	weak	play

All attributes are evaluated at the root node to find the acceptable trees so that there are 4 possible root nodes (Figure C-1).

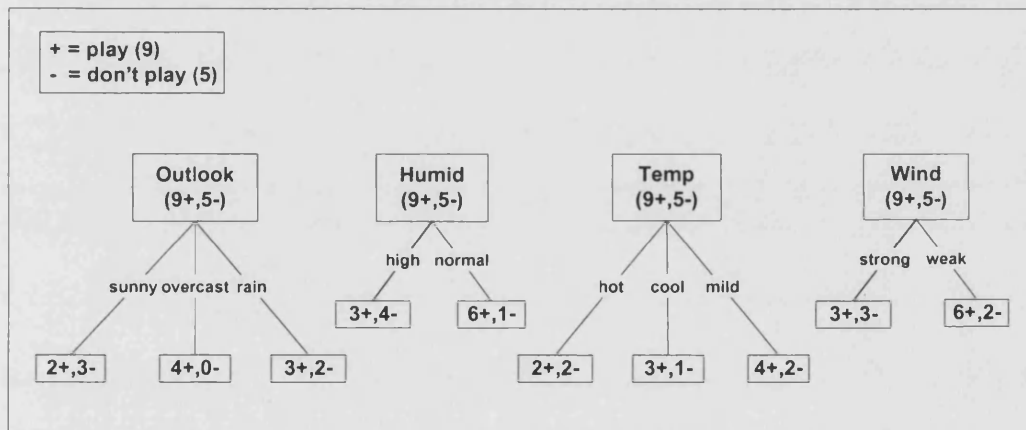


Figure C-1: The illustration of all possible attributes evaluated at root node along with a number of sorted instances in each descendant node.

Suppose S is a collection of 14 instances of a training data set for the decision "play tennis" (Table C-1). There are 9 positive and 5 negative instances for "play tennis", which is denoted as $[9+, 5-]$ (Figure C-1). Then the entropy of S relative to this classification is

$$\begin{aligned} \text{Entropy}(S) &= -\left(\frac{9}{9+5}\right)\left(\log_2\left(\frac{9}{9+5}\right)\right) - \left(\frac{5}{9+5}\right)\left(\log_2\left(\frac{5}{9+5}\right)\right) \\ &= 0.940 \end{aligned} \quad (1)$$

This is the average information needed to identify the class of 'play' and 'don't play' in a training data set. All possible 4 attributes including outlook, temperature, humidity, and wind are to be evaluated at root node to find out the attribute which give the highest information gain.

Firstly, outlook attribute is tested, three subsets according to its 3 values (sunny, overcast, rain) are results using outlook for partitioning the training data set. The first one with two 'play' and three 'don't play' (sunny (2+, 3-)), the second with four play and none 'don't play' (overcast (4+, 0-)), and the third with three 'play' and two 'don't play' (rain (3+, 2-)) (Figure C-1). The computation is

$$\begin{aligned} \text{Entropy (outlook)} &= [5/14 (- (2/5)\log_2(2/5) - (3/5)\log_2(3/5))] + \\ &\quad [4/14 (- (4/4)\log_2(4/4) - (0/4)\log_2(0/4))] + \\ &\quad [5/14 (- (3/5)\log_2(3/5) - (2/5)\log_2(2/5))] \\ &= 0.694 \end{aligned} \quad (2)$$

Secondly, the humid attribute is considered. This would give two subsets (high, normal), one with three "play" and four "don't play" cases (high (3+, 4-)), the other with six "play" and one "don't play" cases (normal (6+, 1-)) (Figure C-1). The similar calculation is

$$\begin{aligned} \text{Entropy (humid)} &= [7/14 (- (3/7)\log_2(3/7) - (4/7)\log_2(4/7))] + \\ &\quad [7/14 (- (6/7)\log_2(6/7) - (1/7)\log_2(1/7))] \\ &= 0.78845 \end{aligned} \quad (3)$$

Thirdly, the attribute temp is tested. Three subsets (hot, cool, mild) are yielded, the first subset with two "play" and two "don't play" cases (hot (2+, 2-)), the second with three "play" and one "don't play" cases (cool (3+, 1-)), and the third with four "play" and two "don't play" cases (mild (4+, 2-)) (Figure C-1). The equivalent computation is

$$\begin{aligned} \text{Entropy (temp)} &= [4/14 (- (2/4)\log_2(2/4) - (2/4)\log_2(2/4))] + \\ &\quad [4/14 (- (3/4)\log_2(3/4) - (1/4)\log_2(1/4))] + \\ &\quad [6/14 (- (4/6)\log_2(4/6) - (2/6)\log_2(2/6))] \\ &= 0.811 \end{aligned} \quad (4)$$

Lastly, we test the attribute windy. This would give two subsets (strong, weak), one with three "play" and three "don't play" cases (strong (3+, 3-)), the other with six "play" and two "don't play" cases (weak (6+, 2-)) (Figure C-1). The entropy computation is

$$\begin{aligned}
 \text{Entropy (wind)} &= \left[\frac{6}{14} \left(- \left(\frac{3}{6} \right) \log_2 \left(\frac{3}{6} \right) - \left(\frac{3}{6} \right) \log_2 \left(\frac{3}{6} \right) \right) \right] + \\
 &\quad \left[\frac{8}{14} \left(- \left(\frac{6}{8} \right) \log_2 \left(\frac{6}{8} \right) - \left(\frac{2}{8} \right) \log_2 \left(\frac{2}{8} \right) \right) \right] \\
 &= 0.892
 \end{aligned} \tag{5}$$

The information gain values for all four attributes are

$$\text{Gain (S, outlook)} = \text{equation (1)} - \text{equation (2)} = 0.940 - 0.694 = 0.246 \text{ bits}$$

$$\text{Gain (S, humidity)} = \text{equation (1)} - \text{equation (3)} = 0.940 - 0.789 = 0.151 \text{ bits}$$

$$\text{Gain (S, temperature)} = \text{equation (1)} - \text{equation (4)} = 0.940 - 0.811 = 0.029 \text{ bits}$$

$$\text{Gain (S, wind)} = \text{equation (1)} - \text{equation (5)} = 0.940 - 0.892 = 0.048 \text{ bits}$$

According to the information gain measure, the outlook attribute provides the best prediction of the decision of play tennis over the training instances. Therefore, outlook is selected as the decision attribute for the root node, and branches are created below the root for each of its values (i.e. sunny, overcast, rain). The resulting partial decision tree is shown in Figure C-2, along with the training instances sorted to each new descendant node. The descendant node from outlook = overcast becomes a leaf node of the tree because all four training cases which fall to this node are homogeneous to 'play tennis' classification (i.e. its entropy is zero). On the other hand, other two descendant nodes from outlook = sunny (node A) and outlook = rain (node B) are not homogeneous yet (i.e. their entropy is nonzero), so that the decision trees will be further elaborated below these nodes.

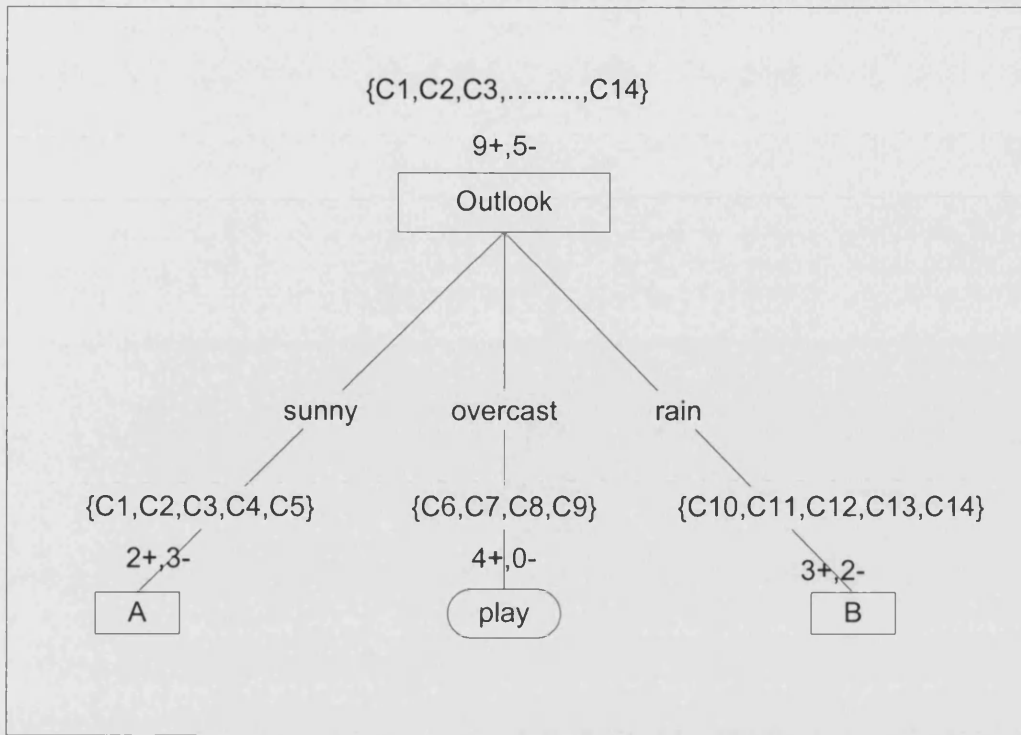


Figure C-2: A partial decision tree for the classification of play tennis.

The process of selecting a new attribute and partitioning the training data set is now repeated for each nonterminal descendant node. The training instances associated with that node are included in the process. Attributes that have been incorporated higher in the tree are excluded, so that any given attributes are used only once along any path through the tree. This process continues for each new leaf node until either of two conditions is met:

1. every attribute has already been included along this path through the tree, or
2. the training instances associated with this leaf node all have the same target attribute value (i.e. their entropy is zero)

The following is the brief computation of information gain for the next step in growing the decision tree.

At node A, the training instances to be partitioned is $S_{\text{sunny}} = \{C1, C2, C3, C4, C5\}$.

The average information gain for partitioning all instances in this set is

$$\begin{aligned} \text{Entropy}(S_{\text{sunny}}) &= -\left(\frac{2}{2+3}\right)\left(\log_2\left(\frac{2}{2+3}\right)\right) - \left(\frac{3}{2+3}\right)\left(\log_2\left(\frac{3}{2+3}\right)\right) \\ &= 0.970 \end{aligned} \quad (6)$$

$$\begin{aligned} \text{Entropy (humid)} &= [3/5(- (0/3)\log_2(0/3) - (3/3)\log_2(3/3))] + \\ &\quad [2/5(- (2/2)\log_2(2/2) - (0/2)\log_2(0/2))] \\ &= 0 \end{aligned} \quad (7)$$

$$\begin{aligned} \text{Entropy (temp)} &= [2/5(- (0/2)\log_2(0/2) - (2/2)\log_2(2/2))] + \\ &\quad [2/5(- (1/2)\log_2(1/2) - (1/2)\log_2(1/2))] + \\ &\quad [1/5(- (1/1)\log_2(1/1) - (0/1)\log_2(0/1))] \\ &= 0.400 \end{aligned} \quad (8)$$

$$\begin{aligned} \text{Entropy (wind)} &= [2/5(- (1/2)\log_2(1/2) - (1/2)\log_2(1/2))] + \\ &\quad [3/5(- (1/3)\log_2(1/3) - (2/3)\log_2(2/3))] \\ &= 0.851 \end{aligned} \quad (9)$$

The information gain values for all three attributes are

$$\begin{aligned} \text{Gain (S}_{\text{sunny}}, \text{ humidity}) &= \text{equation (6)} - \text{equation (7)} \\ &= 0.970 - 0.789 = 0.151 \text{ bits} \end{aligned}$$

$$\begin{aligned} \text{Gain (S}_{\text{sunny}}, \text{ temperature}) &= \text{equation (6)} - \text{equation (8)} \\ &= 0.970 - 0.811 = 0.029 \text{ bits} \end{aligned}$$

$$\begin{aligned} \text{Gain (S}_{\text{sunny}}, \text{ wind}) &= \text{equation (6)} - \text{equation (9)} \\ &= 0.970 - 0.892 = 0.048 \text{ bits} \end{aligned}$$

Therefore, attribute humidity which gives the highest information gain is selected for partitioning the training instances, and two leaf nodes result, i.e. “3 play” (high) and “2 don’t play” (normal) classification (Figure C-3).

Similarly, at node B the attribute which gives the highest information gain values is wind, and two leaf nodes of “2 play” (strong) and “3 don’t play” (weak) result (Figure C-3).

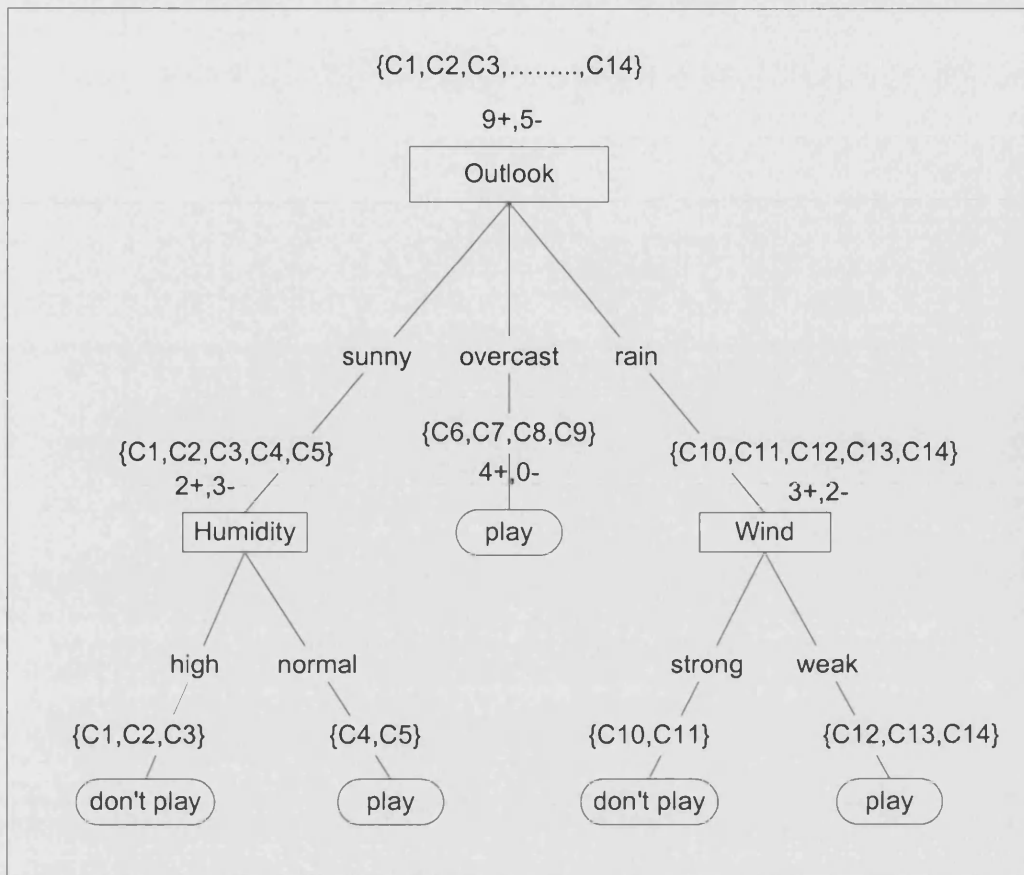


Figure C-3: A full grown decision tree for the classification of play tennis. + = play tennis, - = don't play tennis, C1, ..., C14 = cases in the dataset.

Although, the information gain measure for selecting an attribute gives good results, this criterion has a serious deficiency – it has a strong bias in favour of attributes with many values over those with few values (Quinlan 1993).

Therefore, the information gain ratio criterion is employed to overcome this bias. The gain ratio criterion is claimed to be robust, gives a consistently better choice of test attribute than the gain criterion (Quinlan 1993). The gain information ratio is defined as

$$\text{GainRatio}(S, A) \equiv \frac{\text{Gain}(S, A)}{\text{SplitInformation}(S, A)}$$

Split Information is simply the entropy of a training set S with respect to the values of attribute A , and is defined as

$$\text{SplitInformation}(S, A) \equiv - \sum_{i=1}^c \frac{|S_i|}{|S|} \log_2 \frac{|S_i|}{|S|}$$

where S_1 through S_c are the c subsets of instances resulting from partitioning S by the c -valued attribute A .

The gain ratio measure discourages the selection of attributes with many values because split information will penalise this as it is a denominator of Gain (S, A). This compensates for the bias from the gain information measure. C4.5 and C5.0, which are later than the original ID3 algorithm, employ the gain information ratio.

C.2. Standard Format for Data Preparation in Data Mining

The most convenient format for the data mining data table is a flat file, with one line for each individual record as shown in Figures C-4 and C-5, which are the two most common text files for making a flat file in data mining software. Differentiation of two text files is the implementation of variable separation i.e. a variable width file with a comma delimited as a separator (Figure C-4) and a fixed width file, for which the width of columns are fixed (Figure C-5).

```
1,"pain","bilateral","diffuse","constant","throbbing","nil","afternoon","not applicable","Atypical facial pain (AFP)"
2,"pain","unilateral","localised","intermittent","dull ache","nil","afternoon","hours","Atypical odontalgia (AO)"
3,"clicking or crepitus","bilateral","not applicable","not applicable","not applicable","nil","anytime of the day","sec"
4,"pain","unilateral","localised","constant","dull ache","nil","anytime of the day","hours","Facial Arthralgia (F&M)"
5,"pain","unilateral","localised","constant","dull ache","nil","anytime of the day","not applicable","Facial Arthralgia"
```

Figure C-4: An example of data in a variable width file with comma delimited as a separator for each field. The width of field varied depending on the value in that field and comma is used as a separator for each field.

1	pain	bilateral	diffuse	constant	throbbing	nil	afternoon
2	pain	unilateral	localised	intermittent	dull ache	nil	afternoon
3	clicking or crepitus	bilateral	not applicable	not applicable	not applicable	nil	anytime of the day
4	pain	unilateral	localised	constant	dull ache	nil	anytime of the day
5	pain	unilateral	localised	constant	dull ache	nil	anytime of the day

Figure C-5: An example of data in a fixed width field file. The width of field is fixed for every field.

There are two standard formats for values in a field; categorical variable and numerical variable. The verbal severity scale of pain is a categorical variable since it takes 3 related values (i.e. mild, moderate, severe). A true-or-false variable is also a categorical variable which describes an event where one of

two mutually exclusive events occurs. The value of a numerical variable could also be a measurement such as the number of years a patient has suffered from pain, or it could be an artificial measurement such as index reflecting the severity of pain.

To construct a data mining table, SQL statements are needed to retrieve the data from various tables which joined by linking field. The basic structure of SQL statements is the “select-from-where” expression or query, which has the form:

```
SELECT    attribute 1, attribute 2, ... , attribute p
FROM      table 1, table 2, .... , table k
WHERE     list of conditions
```

The meaning of this statement is that for each possible choice of rows (row 1, row 2, ... , row k) in the table 1, table 2, , table k , we test whether the conditions are true. If they are, a row consisting of the values of the attributes that we want is output. The second line, the from clause, specifies the tables to which the SQL statement is applied. The third line, the where clause, specifies the conditions that the rows in those tables must satisfy to be accepted into the result of the statement. The first line, the select clause, then specifies which attributes of the participating tables should appear in the result. The query functionality in Access offers a user-friendly interface. Users can work with SQL statement via a graphic interface.

C.3. Clementine Software Description

The interface is divided into 3 main areas, working area, palette area, and model generating area (Figure C-6). Icons representing data files and operations are selected from a palette area and placed on a working area (Figure C-6).

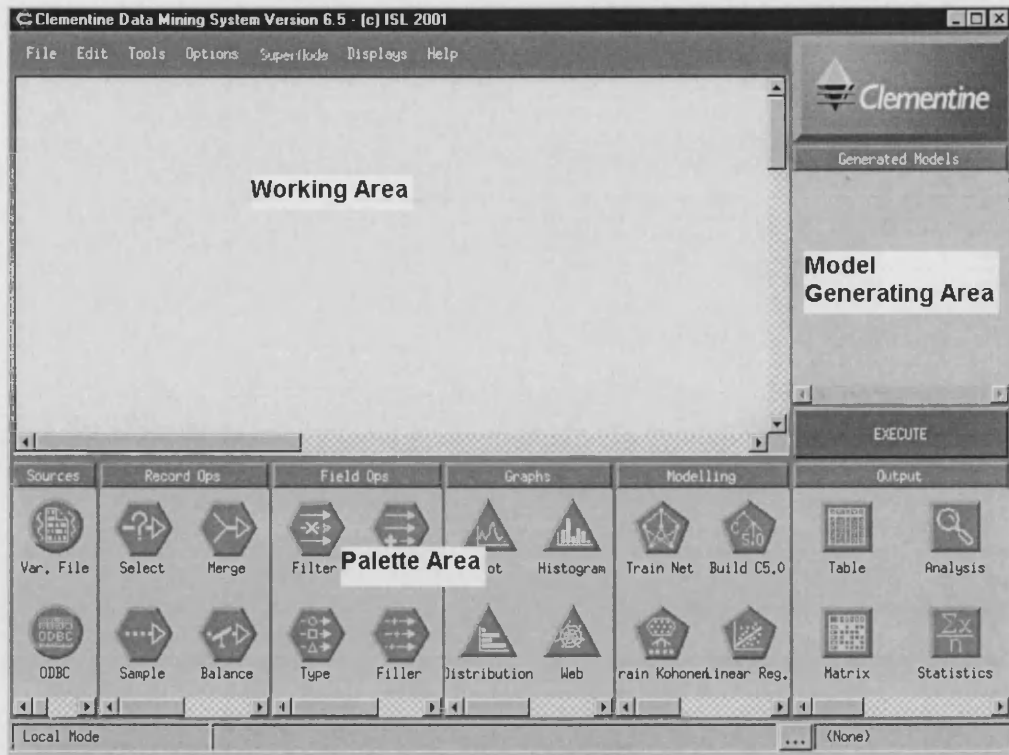


Figure C-6: Interface of Clementine consists of 3 main areas i.e. working area, palette area, and model generating area.

The stream is the connection of source nodes, operation nodes, graph node, and model nodes (Figure C-7).

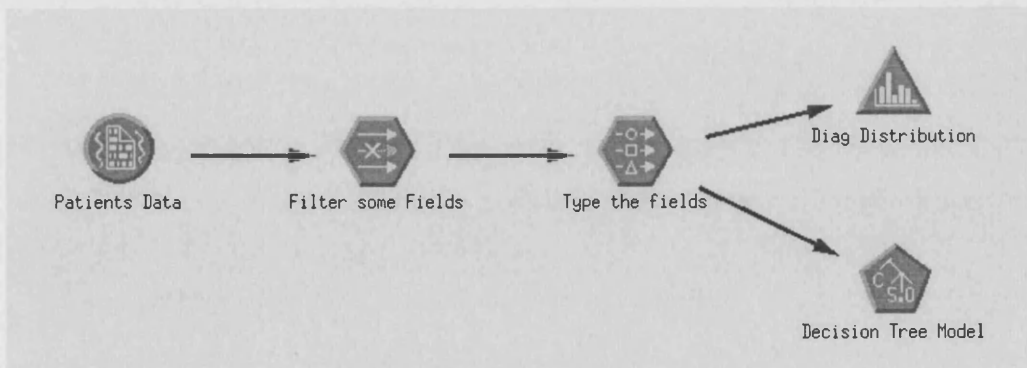


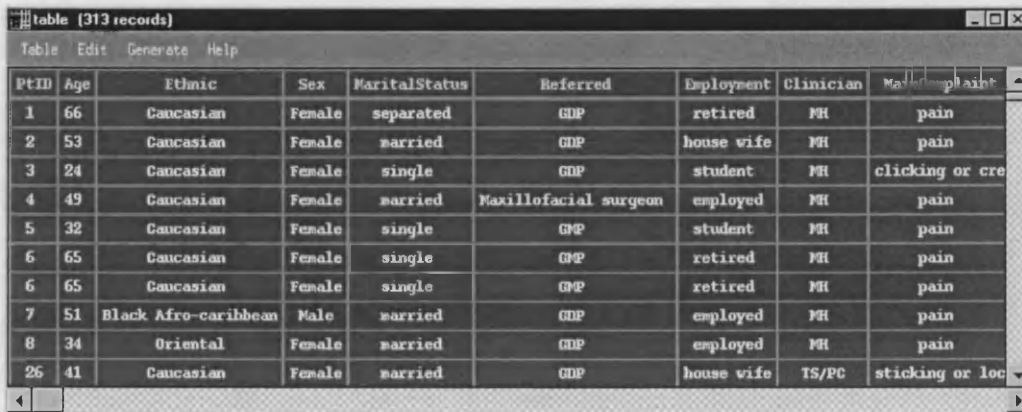
Figure C-7: Illustration of the Clementine working stream.

The output nodes including table, analysis, matrix, and statistics are used for displaying results. To operate a task,

- firstly, the request is executed,
- then data is obtained from data file via a source node,
- data is manipulated in the operation nodes, and

- results are displayed in the output nodes.

An example of a simple common task in Clementine is an inspection of the transferred data using table output node, for which when executed, produces a tabular summary of the data (Figure C-8).



PtID	Age	Ethnic	Sex	MaritalStatus	Referred	Employment	Clinician	MainComplaint
1	66	Caucasian	Female	separated	GDP	retired	PH	pain
2	53	Caucasian	Female	married	GDP	house wife	PH	pain
3	24	Caucasian	Female	single	GDP	student	PH	clicking or cre
4	49	Caucasian	Female	married	Maxillofacial surgeon	employed	PH	pain
5	32	Caucasian	Female	single	GDP	student	PH	pain
6	65	Caucasian	Female	single	GDP	retired	PH	pain
6	65	Caucasian	Female	single	GDP	retired	PH	pain
7	51	Black Afro-caribbean	Male	married	GDP	employed	PH	pain
8	34	Oriental	Female	married	GDP	employed	PH	pain
26	41	Caucasian	Female	married	GDP	house wife	TS/PC	sticking or loc

Figure C-8: Illustration of a tabular summary of data from a table output node.

Visual inspection of the data sets gives a better understanding of variations of the data. Moreover, it can be helpful to detect any abnormalities hidden in the data sets. It also can be helpful to see the distributions of interested fields, such as age and diagnosis classification. The biases and correlation can be identified and may need to be taken into account to enhance the results of the induced models. For example, Figure C-9 illustrates diseases frequency which is quickly and simply detected a small diagnostic group by a graph rather than by directly inspecting the huge data table of a thousand records. Therefore, small diagnostic groups need to be excluded for making a reliable induced model for diagnosis. Figure C-9 also illustrates the correlation of distribution of diseases and age of the entire data. So that, we can see that TMJ disc displacement with reduction (DDWR) is prevalent in the younger age group as expected.

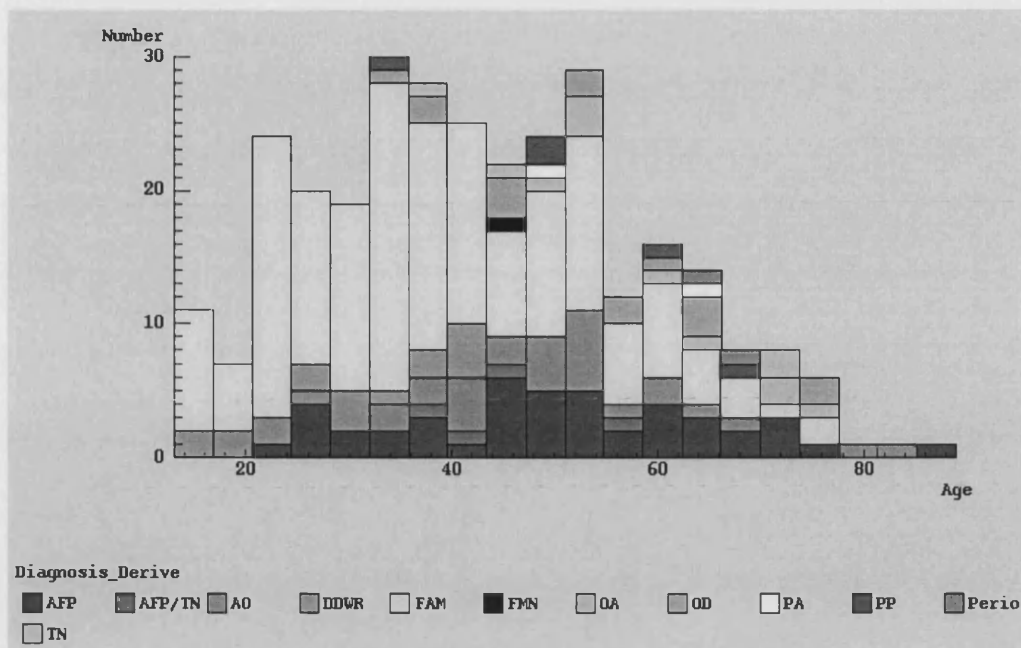


Figure C-9: Clementine graph shows the distribution of diagnosis and age. With this graph, it is easy to detect diseases with low frequency such as FMN (in black), and PA (in white) in the data set. FMN = facial migrainous neuralgia; PA = periapical abscess.

These demonstrate that the visualisation ability of the Clementine system is useful and contributes a benefit for a clean up process of the data set. The system also is user-friendly software.

C.4. The Cross-Validation Method in Data Mining

The 5-folds cross-validation is adopted for testing the accuracy of induced decision tree model for the diagnosis of chronic idiopathic facial pain. There are 5 classes of chronic idiopathic facial pain i.e. facial arthromyalgia (FAM), atypical facial pain (AFP), atypical odontalgia (AO), TMJ disc displacement with reduction (DDWR), and oral dysaesthesia (OD). The participants are randomised into 5 partitions (A, B, C, D, E) using block randomisation and stratified by class of diseases to ensure unbiased and balance of disease classes in each partition. Then one partition is hold for the testing set and the rest for training set until every partition is used.

It is suggested that a block size should not exceed 12 (Smith & Morrow 1996), therefore a block size of 10 was designed and 2 allocations are to be made to partition A, B, C, D, and E. The standard random number table was used to select 2 different one digit random numbers between 0 and 9 by ignoring those numbers that fall outside the range 0-9 or that duplicate a number previously

selected. For example, starting on arbitrary position in the table, suppose numbers 1, 1, 3, 3, 3, 6, 1, 5, 8, 1, 9, 2, 2, 2, 9, 0, 7, 4 were acquired. The sequence obtained is 1, 3, 6, 5, 8, 9, 2, 0, 7, 4. Thus the first, third are allocated to partition A, and the other participants to B, C, D, and E. The complete sequence for the block of 10 is:

Participant:	0	1	2	3	4	5	6	7	8	9
Partition:	D	A	D	A	E	B	B	E	C	C

A similar procedure is used to allocate interventions in the next block until all participants of all five classes (FAM, AFP, AO, DDWR, OD) were picked to all partitions.

The method of randomisation and 5-folds cross-validation process are illustrated in the Figure C-10. The cases in each group are divided randomly using blocked randomisation into 5 groups. Then, the cases from every group are pooled to create 5 partitions, each of which constitutes equally number of representative cases from 5 diagnoses The whole process is repeated 10 times.

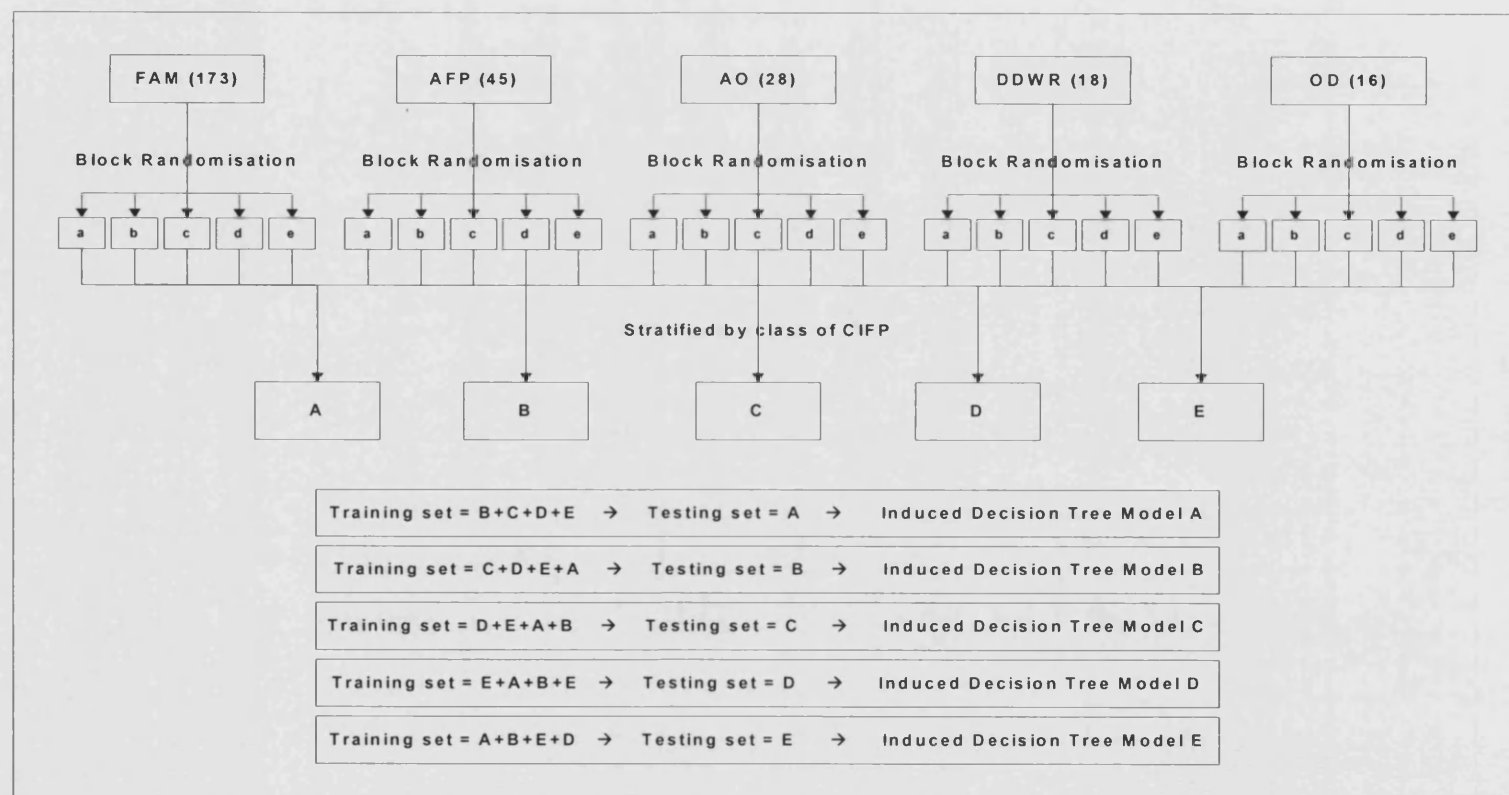


Figure C-10: The diagram depicted the 5-folds cross-validation method by stratified block randomisation of the data set into the testing and training set. Participants in each class of CIFP are randomly labelled as a, b, c, d, e. Then, participants with same labels from 5 classes of CIFP are drawn to partition A, B, C, D, E. CIFP: Chronic Idiopathic Facial Pain.

C.5. The Scoring Method for Ranking the Attributes in the Induced Decision Tree

Frequency of and its level of attributes that can occur in all decision tree models as the result of 10 runs of 5-folds cross-validation are observed. The score are given to each level; level 1 (or root node) has 11 points. The other point of 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 are given to level 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 respectively. The highest score of an attribute can occur when that particular attributes are used as root node for every decision tree models. Therefore, the highest score is $50 \times 11 = 550$, which is equivalent to 100%.

C.6. The Statistics Method for Quantitative Analysis

The agreement and accuracy of the decision tree are described in this section. Kappa statistics is employed to measure the agreement of 2 diagnostic methods. Also the accuracy of the diagnostic test is employed in various analysis including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ration (LR+), negative likelihood ration (LR-). An imprecision sample estimate of the overall population values is expressed in 95% confidence interval which is also described in detail.

C.6.1. Measuring Inter-rater Agreement

Kappa statistics is used to measure 2 alternative diagnostic tests to see how well they agree with each other. Table C-2 depicted the comparison of binary assessments by two observers.

Table C-2: Comparison of binary assessments by two observers

Observer 2	Observer 1		Total
	positive	negative	
positive	a	b	a+b
negative	c	d	c+d
Total	a+c	b+d	a+b+c+d = n

Kappa statistics (κ) has formular as follows:

$$\kappa = \frac{p_o - p_e}{1 - p_e}$$

where p_o is the proportion of samples for which both observers agree given by;

$$p_o = \frac{(a + d)}{n}$$

p_e is the expected proportion of agreements for the whole table is the sum of expected positive and negative agreement;

$$\text{expected positive agreement} = \frac{(a + b)(a + c)}{n^2}$$

$$\text{expected negative agreement} = \frac{(c + d)(b + d)}{n^2}$$

Standard error (SE) of kappa value has formular as follows:

$$SE_k = \sqrt{\frac{p_o(1 - p_e)}{n(1 - p_e)^2}}$$

from which a $100(1-\alpha) \%$ confidence interval for kappa value is as follows:

$$\kappa - Z_{1-\frac{\alpha}{2}} \times SE_k \quad \text{to} \quad \kappa + Z_{1-\frac{\alpha}{2}} \times SE_k$$

Kappa statistics can be extended to more than 2 categories. If there are g categories and f_i is the number of agreements for the i^{th} category, then the overall observed agreement is

$$p_o = \frac{\sum_{i=1}^g f_i}{n}$$

If r_i and c_i are the totals of the i^{th} row and i^{th} column, then the overall expected agreement is

$$p_e = \frac{\sum_{i=1}^g r_i c_i}{n^2}$$

Calculation of κ for data in Table 6-8 (see section 6.3.7.2 in Chapter 6) of the induced decision tree model 1 is as follows:

$$p_o = (7+1+4+35+3)/57$$

$$p_e = (9*10+5*2+4*4+36*38+3*3)/57^2$$

$$\kappa = 0.77$$

$$SE_k = 0.169$$

$$95\% \text{ CI} = 0.77 - (1.96 \cdot 0.169) \text{ to } 0.77 + (1.96 \cdot 0.169)$$

$$= 0.44 \text{ to } 1.0$$

Calculation of κ for data in Table 6-11 (see section 6.3.7.2 in Chapter 6) of the induced decision tree model 2 is as follows:

$$p_o = (7+4+3+31+3)/56$$

$$p_e = (11 \cdot 9 + 6 \cdot 7 + 3 \cdot 4 + 35 \cdot 35 + 3 \cdot 3)/56^2$$

$$\kappa = 0.81$$

$$SE_{\kappa} = 0.0054$$

$$95\% \text{ CI} = 0.81 - (1.96 \cdot 0.0054) \text{ to } 0.81 + (1.96 \cdot 0.0054)$$

$$= 0.80 \text{ to } 0.82$$

C.6.2. Sensitivity (Sens) and Specificity (Spec)

The diagnostic test performance in medicine is adopted to test the classification model. Like Table C-2, the following table illustrates the relation between a binary diagnosis test and presence or absence of the disease (Altman 2000).

Table C-3: Relation between a binary diagnosis test and presence or absence of the disease

	Disease		Total
	positive	negative	
Test positive	a (TP)	b (FP)	a+b
Test negative	c (FN)	d (TN)	c+d
Total	a+c	b+d	a+b+c+d

The two most common indices of the performance of a test are the sensitivity and specificity.

Sensitivity = The proportion of true positives that are correctly identified by the classification decision tree model to the number of cases classified by human as positive, given by $a / (a+c)$ in Table C-3.

Specificity = The proportion of true negatives that are correctly identified by the classification decision tree model to the number of cases classified by human as negative, given by $d / (b+d)$ in Table C-3.

C.6.3. Positive Predictive Value (PPV) and Negative Predictive Value (NPV)

Sensitivity and specificity is not usually applied directly in clinical practice. In clinical setting, the clinician obtain test result for a particular patient, so he/she want to know how good this test can predict the disease. The positive and negative predictive values will give the answer for this (Altman 2000).

Positive predictive value = the proportion of patients with positive test results who are correctly diagnosed, given by $a / (a+b)$ in Table C-3.

Negative predictive value = the proportion of patients with negative test results who are correctly diagnosed, given by $d / (c+d)$ in Table C-3.

C.6.4. Likelihood Ratio (LR)

Likelihood ratio is the ratio of the frequencies of occurrence of this result in patients with the disease (positive likelihood ratio (LR+)) and patients without the disease (negative likelihood ratio (LR-)). The likelihood ratio for positive test result is calculated as

$$LR+ = \text{sensitivity} / (1-\text{specificity})$$

and the likelihood ratio for a negative test result is calculated as

$$LR- = (1-\text{sensitivity}) / \text{specificity}$$

C.6.5. 95% Confidence Interval (CI)

The recommendation method of confidence interval for proportion suggested by Newcombe and Altman (2000) is described as follows;

$$95\% \text{ Confidence Interval} = (A - B)/C \text{ to } (A + B)/C$$

$$\text{where; } A = 2r + z^2; \quad B = z\sqrt{z^2 + 4rq}; \quad C = 2(n + z^2)$$

$$\text{where; } \text{population size} = n$$

$$\text{the estimated proportion who have the feature is } p = r/n$$

$$\text{the proportion who do not have the feature is } q = 1 - p$$

$$\text{the 95\% confidence interval } z = 1.96$$

According to Table C-3, 95% confidence interval of a likelihood ratio can be constructed through a logarithmic transformation suggested by Morris and Gardner (2000) when

$$LR = \frac{a/(a+c)}{b/(b+d)}$$

The standard error of $\log_e LR$ is

$$SE(\log_e LR) = \sqrt{\frac{c}{a(a+c)} + \frac{b}{b(b+d)}}$$

This can be also written as

$$SE(\log_e LR) = \sqrt{\frac{1}{a} - \frac{1}{a+c} + \frac{1}{b} - \frac{1}{b+d}}$$

A 95% confidence interval for R is

$$e^W \quad \text{to} \quad e^X$$

where

$$W = \log_e LR - [z_{1-\alpha/2} \times SE(\log_e LR)]$$

$$X = \log_e LR + [z_{1-\alpha/2} \times SE(\log_e LR)]$$

where

$$z_{1-\alpha/2} = 1.96$$

C.6.6. An Example of the Calculation of Discriminative values

The following section describes the calculation of sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, and negative likelihood ratio showed in Table 6-8 (section 6.3.7.2 of Chapter 6) of the induced decision tree model 1. The contingency tables of atypical facial pain (AFP), atypical odontalgia (AO), TMJ disc displacement with reduction (DDWR), facial arthromyalgia (FAM), and oral dysaesthesia (OD) were derived from Table 6-8 as follows:

Contingency table of diagnosis AFP

	+ve AFP	-ve AFP	Total
C - +ve AFP	7	3	10
C - -ve AFP	2	45	47
Total	9	48	57

AFP

sensitivity = $7/9$ = 0.78 with 95% CI from 0.45 to 0.94

specificity = $45/48$ = 0.94 with 95% CI from 0.83 to 0.98

PPV = $7/10$ = 0.70 with 95% CI from 0.40 to 0.89

NPV = $45/47$ = 0.96 with 95% CI from 0.86 to 0.99

LR + = $0.78/0.06$ = 13

LR - = $0.22/0.94$ = 0.23

Contingency table of diagnosis AO

	+ve AO	-ve AO	Total
C - +ve AO	1	1	2
C - -ve AO	4	51	55
Total	5	52	57

AO

sensitivity = $1/5$ = 0.20

specificity = $51/52$ = 0.98

PPV = $1/2$ = 0.50

NPV = $51/55$ = 0.93

LR + = $0.2/0.12$ = 1.67

LR - = $0.8/0.98$ = 0.82

Contingency table of diagnosis DDWR

	+ve DDWR	-ve DDWR	Total
C - +ve DDWR	4	0	4
C - -ve DDWR	0	53	53
Total	4	53	57

DDWR

sensitivity	= 4/4	= 1
specificity	= 53/53	= 1
PPV	= 4/4	= 1
NPV	= 53/53	= 1
LR +	= 1/0	= infinite
LR -	= 0/1	= 0

Contingency table of diagnosis FAM

	+ve FAM	-ve FAM	Total
C - +ve FAM	35	3	38
C - -ve FAM	1	18	19
Total	36	21	57

FAM

sensitivity	= 35/36	= 0.97
specificity	= 18/21	= 0.86
PPV	= 35/38	= 0.92
NPV	= 18/19	= 0.95
LR +	= 0.97/0.14	= 6.93
LR -	= 0.03/0.86	= 0.03

Contingency table of diagnosis OD

	+ve OD	-ve OD	Total
C - +ve OD	3	0	3
C - -ve OD	0	54	54
Total	3	54	57

OD

sensitivity	= 3/3	= 1
specificity	= 54/54	= 1
PPV	= 3/3	= 1
NPV	= 54/54	= 1
LR +	= 1/0	= infinite
LR -	= 0/1	= 0

C.7. The Other Interesting Induced Decision Trees Resulted from Data Mining

Model C1

The induced decision tree C1 was induced from a training data set of 221 patients under 5% expected noise adjustment and without pain sites. This induced decision tree model was tested on 58 independent unseen patients previously diagnosed by clinicians. The accuracy of this induced decision tree is equivalent to 79%. The kappa statistic which takes into account the chance agreement is used to measure an agreement of this induced decision tree and the clinicians, and the kappa value is with a 95% confidence interval from 0.46 to 0.82

```

1MainComplaint pain [Mode: FAM] (181)
  2tender_muscle_sum <= 0 [Mode: AFP] (44)
    3OtherComplaint2 N/A [Mode: AFP] (0.0) -> AFP
    3OtherComplaint2 ['clicking or crepitus' 'taste change' salivation 'denture intolerance'
    headache earache bruxism 'dry mouth' 'disturbance of oral sensation (eg. Burning)' 'TMJ
    dislocation' pain] [Mode: AFP] (0.0) -> AFP
    3OtherComplaint2 limited mouth opening [Mode: FAM] (1, 1.0) -> FAM
    3OtherComplaint2 sticking or locked jaw [Mode: FAM] (3, 1.0) -> FAM
    3OtherComplaint2 bite discomfort [Mode: FAM] (1, 1.0) -> FAM
    3OtherComplaint2 nil [Mode: AFP] (39)
      4covered_areas <= 2 [Mode: AO] (18)
        5PresentClick 1 [Mode: FAM] (4, 0.75) -> FAM
        5PresentClick 2 [Mode: AO] (14, 0.714) -> AO
      4covered_areas > 2 [Mode: AFP] (21, 0.762) -> AFP
  2tender_muscle_sum > 0 [Mode: FAM] (137)
    3tingling 1 [Mode: AFP] (8)
      4duration_year <= 2.5 [Mode: FAM] (5, 0.8) -> FAM
      4duration_year > 2.5 [Mode: AFP] (3, 1.0) -> AFP
    3tingling 0 [Mode: FAM] (129)
      4alcoholRF 1 [Mode: AFP] (7)
        5TenderPercussion 1 [Mode: AFP] (4, 1.0) -> AFP
        5TenderPercussion 0 [Mode: FAM] (3, 0.667) -> FAM
      4alcoholRF 0 [Mode: FAM] (122)
        5throbbing 1 [Mode: FAM] (28)
          6Diff/localise localised [Mode: FAM] (10)
            7jaw_move_CAF 1 [Mode: FAM] (6, 1.0) -> FAM
            7jaw_move_CAF 0 [Mode: AO] (4, 0.75) -> AO
          6Diff/localise diffuse [Mode: FAM] (18)
            7swellingASS 1 [Mode: FAM] (6, 1.0) -> FAM
            7swellingASS 0 [Mode: AFP] (12)
              8dullache 1 [Mode: AFP] (6, 1.0) -> AFP
              8dullache 0 [Mode: FAM] (6, 0.5) -> FAM
            6Diff/localise not applicable [Mode: FAM] (0.0) -> FAM
          5throbbing 0 [Mode: FAM] (94, 0.926) -> FAM
1MainComplaint clicking or crepitus [Mode: DDWR] (18)
  2Distribution unilateral [Mode: FAM] (9, 0.889) -> FAM
  
```

2Distribution bilateral [Mode: DDWR] (9, 1.0) -> DDWR
 1MainComplaint limited mouth opening [Mode: FAM] (4, 1.0) -> FAM
 1MainComplaint sticking or locked jaw [Mode: DDWR] (4, 0.5) -> DDWR
 1MainComplaint TMJ dislocation [Mode: FAM] (0.0) -> FAM
 1MainComplaint disturbance of oral sensation (eg. Burning) [Mode: OD] (6, 1.0) -> OD
 1MainComplaint headache [Mode: FAM] (1, 1.0) -> FAM
 1MainComplaint tinnitus [Mode: DDWR] (2, 0.5) -> DDWR
 1MainComplaint taste change [Mode: OD] (4, 1.0) -> OD
 1MainComplaint bite discomfort [Mode: FAM] (1, 1.0) -> FAM

Figure C-11: The induced decision tree C1 for the diagnosis of CIFF. The number in front of each line indicates the level depth of the branch of tree. FAM = facial arthromyalgia, AO = atypical odontalgia, AFP = atypical facial pain, DDWR = TMJ disc displacement with reduction, OD = oral dysaesthesia, CAF = current aggravating factors, RF = relieving factors, ASS = associated symptoms and signs, N/A = not applicable, PresentClick 1 = yes for clicking, PresentClick 2 = no for clicking. The value 1, 0 after some attributes means yes, no respectively.

Model C2

The induced decision tree C2 was induced from a training data set of 225 patients under 5% expected noise adjustment and removed specific pain sites while the model was learning. The result is an induced decision tree for classification of chronic idiopathic facial pain as follows. The accuracy is 43 out of 57 patients, or equivalent to a proportion of 0.76. The kappa value is 0.54 with a 95% confidence interval from 0.23 to 0.85

1MainComplaint pain [Mode: FAM] (183)
 2jaw_move_CAF 1 [Mode: FAM] (113)
 3duration_year <= 20 [Mode: FAM] (109, 0.881) -> FAM
 3duration_year > 20 [Mode: AFP] (4, 0.75) -> AFP
 2jaw_move_CAF 0 [Mode: AFP] (70)
 3sweatingASS 1 [Mode: AFP] (4, 1.0) -> AFP
 3sweatingASS 0 [Mode: FAM] (66)
 4Frequency constant [Mode: AFP] (31)
 5alteredtasteASS 1 [Mode: AO] (4, 0.75) -> AO
 5alteredtasteASS 0 [Mode: AFP] (27, 0.593) -> AFP
 4Frequency intermittent [Mode: FAM] (35)
 5covered_areas <= 2 [Mode: AO] (17)
 6PresentClick 1 [Mode: FAM] (5, 0.8) -> FAM
 6PresentClick 2 [Mode: AO] (12, 0.917) -> AO
 5covered_areas > 2 [Mode: FAM] (18)
 6tender_muscle_sum <= 0 [Mode: AFP] (6)
 7PresentClick 1 [Mode: FAM] (3, 0.667) -> FAM
 7PresentClick 2 [Mode: AFP] (3, 1.0) -> AFP
 6tender_muscle_sum > 0 [Mode: FAM] (12, 1.0) -> FAM
 4Frequency not applicable [Mode: FAM] (0.0) -> FAM
 1MainComplaint clicking or crepitus [Mode: DDWR] (17)
 2Frequency constant [Mode: DDWR] (0.0) -> DDWR
 2Frequency intermittent [Mode: FAM] (11)
 3Distribution unilateral [Mode: FAM] (7, 1.0) -> FAM
 3Distribution bilateral [Mode: DDWR] (4, 0.75) -> DDWR
 2Frequency not applicable [Mode: DDWR] (6, 1.0) -> DDWR

1MainComplaint limited mouth opening [Mode: FAM] (4, 1.0) -> FAM
 1MainComplaint sticking or locked jaw [Mode: DDWR] (5, 0.6) -> DDWR
 1MainComplaint TMJ dislocation [Mode: DDWR] (1, 1.0) -> DDWR
 1MainComplaint disturbance of oral sensation (eg. Burning) [Mode: OD] (5, 1.0) -> OD
 1MainComplaint headache [Mode: FAM] (1, 1.0) -> FAM
 1MainComplaint tinnitus [Mode: FAM] (1, 1.0) -> FAM
 1MainComplaint taste change [Mode: OD] (4, 1.0) -> OD
 1MainComplaint bite discomfort [Mode: FAM] (1, 1.0) -> FAM

Figure C-12: The induced decision tree C2 for the diagnosis of CIFP. The number in front of each line indicates the level depth of the branch of tree. FAM = facial arthromyalgia, AO = atypical odontalgia, AFP = atypical facial pain, DDWR = TMJ disc displacement with reduction, OD = oral dysaesthesia, CAF = current aggravating factors, RF = relieving factors, ASS = associated symptoms and signs, N/A = not applicable, PresentClick 1 = yes for clicking, PresentClick 2 = no for clicking. The value 1, 0 after some attributes means yes, no respectively.

Model C3

This induced decision tree was trained from 222 patients under 5% expected noise adjustment and included specific pain sites while the model was training. The accuracy is 50 out of 57 patients, or equivalent to a proportion of 0.88. The kappa value is 0.77 with a 95% confidence interval from 0.51 to 0.93.

1TMJ 1 [Mode: FAM] (166)
 2oral_mucosa 1 [Mode: AFP] (8)
 3numbnessASS 1 [Mode: AFP] (3, 1.0) -> AFP
 3numbnessASS 0 [Mode: FAM] (5, 0.6) -> FAM
 2oral_mucosa 0 [Mode: FAM] (158)
 3MainComplaint N/A [Mode: FAM] (0.0) -> FAM
 3MainComplaint pain [Mode: FAM] (128)
 4Maxilla 1 [Mode: FAM] (31)
 5bite_chew_CAF 1 [Mode: FAM] (20)
 6tender_muscle_sum =< 1 [Mode: AFP] (3, 0.667) -> AFP
 6tender_muscle_sum > 1 [Mode: FAM] (17, 1.0) -> FAM
 5bite_chew_CAF 0 [Mode: AFP] (11)
 6NormalMuE 1 [Mode: AFP] (8)
 7Sex Female [Mode: AFP] (5, 1.0) -> AFP
 7Sex Male [Mode: AO] (3, 0.667) -> AO
 6NormalMuE 0 [Mode: FAM] (3, 0.667) -> FAM
 4Maxilla 0 [Mode: FAM] (97, 0.979) -> FAM
 3MainComplaint clicking or crepitus [Mode: DDWR] (17)
 4Frequency constant [Mode: DDWR] (0.0) -> DDWR
 4Frequency intermittent [Mode: FAM] (11)
 5Distribution unilateral [Mode: FAM] (7, 1.0) -> FAM
 5Distribution bilateral [Mode: DDWR] (4, 0.75) -> DDWR
 4Frequency not applicable [Mode: DDWR] (6, 1.0) -> DDWR
 3MainComplaint limited mouth opening [Mode: FAM] (4, 1.0) -> FAM
 3MainComplaint sticking or locked jaw [Mode: DDWR] (5, 0.6) -> DDWR
 3MainComplaint TMJ dislocation [Mode: DDWR] (1, 1.0) -> DDWR
 3MainComplaint ['disturbance of oral sensation (eg. Burning)' 'taste change'] [Mode: FAM] (0.0) -> FAM
 3MainComplaint headache [Mode: FAM] (1, 1.0) -> FAM
 3MainComplaint tinnitus [Mode: FAM] (1, 1.0) -> FAM

```

3MainComplaint bite discomfort [Mode: FAM] (1, 1.0) -> FAM
1TMJ 0 [Mode: AFP] (56)
  2MainComplaint N/A [Mode: AFP] (0.0) -> AFP
  2MainComplaint pain [Mode: AFP] (47)
    3Dento_alveolar 1 [Mode: AO] (28)
      4nauseaASS 1 [Mode: AFP] (4, 0.75) -> AFP
      4nauseaASS 0 [Mode: AO] (24)
        5redness/hyperemiaASS 1 [Mode: AFP] (4, 0.75) -> AFP
        5redness/hyperemiaASS 0 [Mode: AO] (20, 0.95) -> AO
    3Dento_alveolar 0 [Mode: AFP] (19, 0.789) -> AFP
  2MainComplaint ['clicking or crepitus' 'limited mouth opening' 'sticking or locked jaw' 'TMJ
dislocation' headache tinnitus 'bite discomfort'] [Mode: AFP] (0.0) -> AFP
  2MainComplaint disturbance of oral sensation (eg. Burning) [Mode: OD] (5, 1.0) -> OD
  2MainComplaint taste change [Mode: OD] (4, 1.0) -> OD

```

Figure C-13: The induced decision tree C3 for the diagnosis of CIFP. The number in front of each line indicates the level depth of the branch of tree. FAM = facial arthromyalgia, AO = atypical odontalgia, AFP = atypical facial pain, DDWR = TMJ disc displacement with reduction, OD = oral dysaesthesia, CAF = current aggravating factors, MuE = mucosal examination, ASS = associated symptoms and signs, N/A = not applicable. The value 1, 0 after some attributes means yes, no respectively.

Model C4

This induced decision tree was trained from 224 patients under 5% expected noise adjustment and included specific pain sites while the model was training. This model is tested on independent unseen data set of 55 patients previously diagnosed by clinicians. The accuracy is 47 out of 55 patients, or equivalent to a proportion of 0.85. The kappa value is: 0.72 with a 95% confidence interval from 0.54 to 1.0.

```

1TMJ 1 [Mode: FAM] (168)
  2Infraorbit 1 [Mode: AFP] (9)
    3bite_chew_CAF 1 [Mode: FAM] (4, 0.75) -> FAM
    3bite_chew_CAF 0 [Mode: AFP] (5, 0.8) -> AFP
  2Infraorbit 0 [Mode: FAM] (159)
    3Frequency constant [Mode: FAM] (45)
      4nilCAF 1 [Mode: AFP] (4, 0.75) -> AFP
      4nilCAF 0 [Mode: FAM] (41)
        5Temple 1 [Mode: FAM] (12)
          6PresentClick 1 [Mode: FAM] (5, 1.0) -> FAM
          6PresentClick 2 [Mode: AFP] (7)
            7weatherchangeCAF 1 [Mode: AFP] (4, 1.0) -> AFP
            7weatherchangeCAF 0 [Mode: FAM] (3, 0.667) -> FAM
        5Temple 0 [Mode: FAM] (29, 0.966) -> FAM
    3Frequency intermittent [Mode: FAM] (105, 0.914) -> FAM
    3Frequency not applicable [Mode: DDWR] (9, 1.0) -> DDWR
1TMJ 0 [Mode: AO] (56)
  2MainComplaint N/A [Mode: AO] (0.0) -> AO
  2MainComplaint pain [Mode: AO] (46)
    3Dento_alveolar 1 [Mode: AO] (28)
      4nauseaASS 1 [Mode: AFP] (4, 0.75) -> AFP

```

```

4nauseaASS 0 [Mode: AO] (24)
  5redness/hyperemiaASS 1 [Mode: AFP] (4, 0.75) -> AFP
  5redness/hyperemiaASS 0 [Mode: AO] (20, 0.95) -> AO
3Dento_alveolar 0 [Mode: AFP] (18)
  4burning 1 [Mode: OD] (3, 0.667) -> OD
  4burning 0 [Mode: AFP] (15, 0.867) -> AFP
2MainComplaint ['clicking or crepitus' 'limited mouth opening' 'sticking or locked jaw' 'TMJ
dislocation' headache tinnitus 'bite discomfort'] [Mode: AO] (0.0) -> AO
2MainComplaint disturbance of oral sensation (eg. Burning) [Mode: OD] (6, 1.0) -> OD
2MainComplaint taste change [Mode: OD] (4, 1.0) -> OD

```

Figure C-14: The induced decision tree C4 for the diagnosis of CIPF. The number in front of each line indicates the level depth of the branch of tree. FAM = facial arthromyalgia, AO = atypical odontalgia, AFP = atypical facial pain, DDWR = TMJ disc displacement with reduction, OD = oral dysaesthesia, CAF = current aggravating factors, ASS = associated symptoms and signs, N/A = not applicable, PresentClick 1 = yes for clicking, PresentClick 2 = no for clicking. The value 1, 0 after some attributes means yes, no respectively.

APPENDIX D

CLEMENTINE SYNTAX OF THE DIAGNOSTIC RULES

This Appendix provides the details of the Clementine syntax of the diagnostic rules.

D.1. Rules for Summarising the Diagnosis

The area of pain is a key characteristics of the decision tree to apply the rules for diagnosis. Some condition may present as pain in wide areas on the faces including several divided topographic zones. For example, FAM can present as pain in the TMJ, mandible and maxilla. Therefore, decision tree of pain in TMJ, mandible and maxilla will be applied for this condition. The diagnosis of FAM will be the result for each decision tree. The following rules are the rules which summarised the same resulting diagnosis from all areas.

```
o_Ulc_MuLe
    'om_Apth_MuLe' = "T" or
    'om_MuLe_Dysp' = "T"
```

```
o_Ane_AcCandi
    'om_Ane_AcCandi' = "T"
```

```
j_DDWR
    'tmj_DDWR' = "T"
```

```
jdx_FAM
    'tmj_FAM' = "T" or
    'md_FAM' = "T" or
    'mx_FAM' = "T"
```

```
j_OAthesis
    'tmj_OAthesis' = "T"
```

```
j_OA
    'tmj_OA' = "T"
```

```
jdx_RhA
    'tmj_RhA' = "T" or
    'md_RhA' = "T" or
    'mx_RhA' = "T"
```

```
jtdx_AO
    'tmj_AO' = "T" or
    'th_AO' = "T" or
    'md_AO' = "T" or
```

```

'mx_AO' = "T"

ojftdx_AO_AFP
'th_AO_AFP' = "T" or
'md_AO_AFP' = "T" or
'mx_AO_AFP' = "T"

ojftdx_AFP
'om_AFP' = "T" or
'tmj_AFP' = "T" or
'fr_AFP_TH' = "T" or
'md_AFP' = "T" or
'mx_AFP' = "T"

dx_AFP_refPain
'md_refPain_AFP' = "T" or
'mx_refPain_AFP' = "T"

t_refPain
'th_refPain' = "T"

tdx_AO_refPain
'th_AO_refPain' = "T" or
'md_AO_refPain' = "T" or
'mx_AO_refPain' = "T"

jfdx_hybAFP/TN
'tmj_HybAFP/TN' = "T" or
'fr_HybAFP/TN' = "T" or
'md_hybAFP/TN' = "T" or
'mx_hybAFP/TN' = "T"

ojfdx_TN
'om_TN_GN' = "T" or
'tmj_TN' = "T" or
'fr_TN' = "T" or
'md_TN' = "T" or
'mx_TN' = "T"

jfdx_PostHerpNeug
'tmj_PostHerpNeug' = "T" or
'fr_PostHerpNeug' = "T" or
'md_PostHerpNeug' = "T" or
'mx_PostHerpNeug' = "T"

ojfdx_intcraLesion
'om_SecNeug' = "T" or
'tmj_intcraTu_Aneu_NasoCA_MS' = "T" or
'fr_MS_intcraTu_Aneu' = "T" or
'fr_intcraTu_Aneu' = "T" or
'fr_intcraHmg_SpaceOccuLesion' = "T" or
'md_intcraTu_Aneu_NasoCA_MS' = "T" or
'mx_intcraTu_NasoCA_MS_Aneu' = "T"

fx_FMN
'fr_FMN' = "T" or
'mx_FMN' = "T"

tdx_Pulpitis_w_wo_AP
'th_revPP' = "T" or
'th_PTrevPP/AAP' = "T" or
'th_revPP/AP' = "T" or
'th_PTrevPP/AP' = "T" or
'th_irrPP/AAP' = "T" or

```



```

'th_PTirrPP/AAP' = "T" or
'th_irrPP/AP' = "T" or
'th_PTirrPP/AP' = "T" or
'md_revPP' = "T" or
'md_PTrevPP/AAP' = "T" or
'md_revPP/AP' = "T" or
'md_PTrevPP/AP' = "T" or
'md_irrPP/AAP' = "T" or
'md_PTirrPP/AAP' = "T" or
'md_irrPP/AP' = "T" or
'md_PTirrPP/AP' = "T" or
'mx_revPP' = "T" or
'mx_PTrevPP/AAP' = "T" or
'mx_revPP/AP' = "T" or
'mx_PTrevPP/AP' = "T" or
'mx_irrPP/AAP' = "T" or
'mx_PTirrPP/AAP' = "T" or
'mx_irrPP/AP' = "T" or
'mx_PTirrPP/AP' = "T"

tdx_revPP_CrTh
'th_revPP_CrTh' = "T" or
'md_revPP_CrTh' = "T" or
'mx_revPP_CrTh' = "T"

tdx_CrTh
'th_CrTh' = "T" or
'th_CrTh/irrPP' = "T" or
'md_CrTh' = "T" or
'md_CrTh/irrPP' = "T" or
'mx_CrTh' = "T" or
'mx_CrTh/irrPP' = "T"

tdx_Pnec/AAP
'th_PNec/AAP' = "T" or
'th_PTnec/AAP' = "T" or
'md_Pnec/AAP' = "T" or
'md_PTnec/AAP' = "T" or
'mx_Pnec/AAP' = "T" or
'mx_PTnec/AAP' = "T"

tdx_AAP
'th_AAP' = "T" or
'md_AAP' = "T" or
'mx_AAP' = "T"

tdx_Pnec/AAP_FxEndoTh
'th_PNec/AAP_FxEndoTh' = "T" or
'md_Pnec/AAP_FxEndoTh' = "T" or
'mx_Pnec/AAP_FxEndoTh' = "T"

tdx_PosResSen
'th_PosResSen' = "T" or
'md_PosResSen' = "T" or
'mx_PosResSen' = "T"

tdx_DenSen
'th_DenSen' = "T" or
'md_DenSen' = "T" or
'mx_DenSen' = "T"

tdx_intOssLesion
'th_intOssPath' = "T" or
'md_intOssPath' = "T" or

```



```

'md_ChroOssCyst_IntOssTu' = "T" or
'md_MalIntOssTu' = "T" or
'mx_intOssPath' = "T" or
'mx_OdonCyst/Tu_CA' = "T"

tdx_Endo/Perio
'th_EndoPerio' = "T" or
'md_Endo/Perio' = "T" or
'mx_EndoPerio' = "T"

tdx_Perio
'th_Perio' = "T" or
'md_Perio' = "T" or
'mx_Perio' = "T"

tdx_Pericoro
'th_Pericoro' = "T" or
'md_Pericoro' = "T" or
'mx_Pericoro' = "T"

jdx_GiArtitis
'tmj_GiArtitis' = "T" or
'md_GiArtitis' = "T" or
'mx_GiArtitis' = "T"

f_Migraine
'fr_Migraine' = "T"

f_Sinus_Mucoce
'fr_Sinu_Mucoce' = "T"

f_Hypertension
'fr_Hypertension' = "T"

x_MaxSinus
'mx_Sinus' = "T"

x_Sialolith
'mx_Sialolith' = "T"

```

D.2. Diagnostic Rules for Pain in the Frontal Region

```

fr_R1_PostHerpNeug
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
(touchCAF' = "1" or 'triggerpointASS' = "1") and
('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' = "1" or
'burning' = "1") and
('historyvesiclePRPPMH' = "1")

fr_AFP/TN
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
(touchCAF' = "1" or 'triggerpointASS' = "1" and
('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' or
'burning' = "1") and
not('historyvesiclePRPPMH' = "1") and
('norm_CN_finding' = "1")

```

```

fr_R3_MS_intracraTu_Aneu
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
   'OtherComplaint2' = "pain") and
  ('Frontal' = "1" or 'Supraorbit' = "1") and
  ('sharp' = "1" or 'electric_liked' = "1") and
  ('touchCAF' = "1" or 'triggerpointASS' = "1") and
  ('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' = "1" or
   'burning' = "1") and
  not('historyvesiclePRPPMH' = "1") and
  not('norm_CN_finding' = "1")

fr_R4_TN
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
   'OtherComplaint2' = "pain") and
  ('Frontal' = "1" or 'Supraorbit' = "1") and
  ('sharp' = "1" or 'electric_liked' = "1") and
  ('touchCAF' = "1" or 'triggerpointASS' = "1") and
  not('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' = "1"
   or 'burning' = "1")

fr_R5_AFP_TH
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
   'OtherComplaint2' = "pain") and
  ('Frontal' = "1" or 'Supraorbit' = "1") and
  ('sharp' = "1" or 'electric_liked' = "1") and
  not('touchCAF' = "1" or 'triggerpointASS' = "1") and
  ('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' = "1" or
   'burning' = "1") and
  ('norm_CN_finding' = "1")

fr_R6_MS_intracraTu_Aneu
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
   'OtherComplaint2' = "pain") and
  ('Frontal' = "1" or 'Supraorbit' = "1") and
  ('sharp' = "1" or 'electric_liked' = "1") and
  not('touchCAF' = "1" or 'triggerpointASS' = "1") and
  ('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' or
   'burning' = "1") and
  not('norm_CN_finding' = "1")

fr_R7_AFP_TH
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
   'OtherComplaint2' = "pain") and

fr_R8_Sinu_Mucoce
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
   'OtherComplaint2' = "pain") and
  ('Frontal' = "1" or 'Supraorbit' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
  ('dullache' = "1" or 'throbbing' = "1") and
  ('nasalstiffness/obstructionASS' = "1") and
  ('RadiopaqueXray' = "1")

fr_R9_FMN
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
   'OtherComplaint2' = "pain") and
  ('Frontal' = "1" or 'Supraorbit' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
  ('dullache' = "1" or 'throbbing' = "1") and
  ('nasalstiffness/obstructionASS' = "1") and
  not('RadiopaqueXray' = "1")

fr_R10_Sinu_Mucoce

```

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1" )and
not('nasalstiffness/obstructionASS' = "1" ) and
('BP_normal' = "1") and
('RadiopaqueXray' = "1")

fr_R11_Hypertension
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('nasalstiffness/obstructionASS' = "1") and
not('BP_normal' = "1")

fr_R12_AFP_TH
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1") and
not('sharp' = "1" or 'electric_liked' = "1" )and
('dullache' = "1" or 'throbbing' = "1") and
not('nasalstiffness/obstructionASS' = "1") and
('BP_normal' = "1") and
not('RadiopaqueXray' = "1") and
('numbness' = "1" or 'tingling' = "1" or 'burning' = "1" or
'numbnessASS' = "1") and
('norm_CN_finding' = "1")

fr_R13_intracraTu_Aneu
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1" )and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('nasalstiffness/obstructionASS' = "1") and
('BP_normal' = "1") and
not('RadiopaqueXray' = "1") and
('numbness' = "1" or 'tingling' = "1" or 'burning' = "1" or
numbnessASS' = "1") and
not('norm_CN_finding' = "1")

fr_R14_intcraHmg_SpaceOccuLesion
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('nasalstiffness/obstructionASS' = "1" )and
('BP_normal' = "1") and
not('RadiopaqueXray' = "1")and
not('numbness' = "1" or 'tingling' = "1" or 'burning' or
numbnessASS' = "1") and
('lightCAF' = "1" or 'nauseaASS' = "1") and
('NeckStiff' = "1" or 'Papilloedema' = "1")

fr_R15_Migraine
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1") and
not('sharp' = "1" or 'electric_liked' = "1")and
('dullache' = "1" or 'throbbing' = "1") and

```

```

not('nasalstiffness/obstructionASS' = "1" ) and
('BP_normal' = "1" )and
not('RadiopaqueXray' = "1") and
not('numbness' = "1" or 'tingling' = "1" or 'burning' = "1" or
'numbnessASS' = "1") and
(lightness' = "1" or 'nauseaASS' = "1") and
not('NeckStiff' = "1" or 'Papilloedema' = "1")

```

```

fr_R16_TH_AFP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Frontal' = "1" or 'Supraorbit' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1" )and
not('nasalstiffness/obstructionASS' = "1") and
('BP_normal' = "1") and
not('RadiopaqueXray' = "1") and
not('numbness' = "1" or 'tingling' = "1" or 'burning' = "1" or
numbnessASS' = "1") and
not('lightCAF' = "1" or 'nauseaASS' = "1")

```

There are many rules for the same diagnosis, therefore, the diagnosis of a particular pain can be derived from several rules. The following paragraph is summary of those rules.

```

fr_PostHerpNeug
'fr_R1_PostHerpNeug' = "T"

fr_hybAFP/TN
'fr_R2_hybAFP/TN' = "T"

fr_MS_intcraTu_Aneu
'fr_R3_MS_intcraTu_Aneu' = "T" or
'fr_R6_MS_intcraTu_Aneu' = "T"

fr_intcraTu_Aneu
'fr_R13_intcraTu_Aneu' = "T"

fr_intcraHmg_SpaceOccuLesion
'fr_R14_intcraHmg_SpaceOccuLesion' = "T"

fr_TN
'fr_R4_TN' = "T"

fr_AFP_TH
'fr_R5_AFP_TH' = "T" or
'fr_R7_AFP_TH' = "T" or
'fr_R12_AFP_TH' = "T" or
'fr_R16_AFP_TH' = "T"

fr_Sinu_Mucoce
'fr_R8_Sinu_Mucoce' = "T" or
'fr_R10_Sinu_Mucoce' = "T"

fr_FMN
'fr_R9_FMN' = "T"

fr_Hypertension
'fr_R11_Hypertension' = "T"

fr_Migraine

```

```
'fr_R15_Migraine' = "T"
```

D.3. Diagnostic Rules of Pain in the TMJ and Temporoparietal Region

```
tmj_R1_DDWR
  ('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
  not('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
  ('MainComplaint' = "clicking or crepitus" or 'MainComplaint' =
"sticking or locked jaw" or 'MainComplaint' = "TMJ dislocation")
and
  not('ErosionXray' = "1" or 'OsteophyteXray' = "1")

tmj_R2_OAthesis
  ('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
  not('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
  ('MainComplaint' = "clicking or crepitus" or 'MainComplaint' =
"sticking or locked jaw" or 'MainComplaint' = "TMJ dislocation")
and
  ('ErosionXray' = "1" or 'OsteophyteXray' = "1")

tmj_R3_FAM
  ('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
  ('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
  ('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or
  'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' = "1")
and
  (not('tender_TMJ_E' = "nil") or 'tender_muscleE' = "1") and
  ('MaxOpen' < 30) and
  not('ErosionXray' = "1" or 'OsteophyteXray' = "1")

tmj_R4_OA
  ('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
  ('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
  ('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or
  'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' = "1")
and
  (not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
  'MaxOpen' < 30) and
  ('ErosionXray' = "1" or 'OsteophyteXray' = "1") and
  ('rheumatoid factor' = "0" or 'rheumatoid factor' = "1")

tmj_R5_RhA
  ('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
  ('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
  ('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or
  'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' = "1")
and
  (not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
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('MaxOpen' < 30) and
('ErosionXray' = "1" or 'OsteophyteXray' = "1") and
not('rheumatoid factor' = "0" or 'rheumatoid factor' = "1")

tmj_R6_FAM
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or
'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' = "1")
and
(not('tender_TMJ_E' = "nil") or 'tender_muscleE' = "1") and
('MaxOpen' >= 30) and
((not('RightOpenClick' = "1") and not('RightCloseClick' = "1"))
or
(not('LeftOpenClick' = "1") and not('LeftCloseClick' = "1")))

tmj_R7_FAM
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or
'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' = "1") and
(not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
('MaxOpen' >= 30) and
not((not('RightOpenClick' = "1") and not('RightCloseClick' =
"1")) or
(not('LeftOpenClick' = "1") and not('LeftCloseClick' = "1"))))
and
not('ErosionXray' = "1" or 'OsteophyteXray' = "1")

tmj_R8_OA
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or
'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' = "1")
and
(not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
('MaxOpen' >= 30) and
not((not('RightOpenClick' = "1") and not('RightCloseClick' =
"1")) or
(not('LeftOpenClick' = "1") and not('LeftCloseClick' = "1"))))
and
('ErosionXray' = "1" or 'OsteophyteXray' = "1") and
('rheumatoid factor' = "0" or 'rheumatoid factor' = "1")

tmj_R9_RhA
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and

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('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or 'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' =
"1") and
(not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
('MaxOpen' >= 30) and
not((not('RightOpenClick' = "1") and not('RightCloseClick' =
"1")) or
(not('LeftOpenClick' = "1") and not('LeftCloseClick' = "1")))) and
('ErosionXray' = "1" or 'OsteophyteXray' = "1") and
not('rheumatoid factor' = "0" or 'rheumatoid factor' = "1")

tmj_R10_GiArthritis
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or
'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' = "1")
and
not(not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
('ArteryTender' = "1") and
not('ESR' = "0" or 'ESR' = "1"))

tmj_R11_AFP
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or
'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' = "1")
and
not(not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
('ArteryTender' = "1") and
('ESR' = "0" or 'ESR' = "1"))

tmj_R12_AFP
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' = "1"
or 'bitingCAF' = "1" or 'hardfoodCAF' = "1" or 'chewingCAF' =
"1") and
not(not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
not('ArteryTender' = "1"))

tmj_R13_GiArthritis
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
not('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' =
"1" or 'bitingCAF' = "1" or 'hardfoodCAF' = "1" or
'chewingCAF' = "1") and
('ArteryTender' = "1") and
not('ESR' = "0" or 'ESR' = "1")

tmj_R14_AFP

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```

('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "Pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
not('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' =
= "1" or 'bitingCAF' = "1" or 'hardfoodCAF' = "1" or
'chewingCAF' = "1") and
('ArteryTender' = "1") and
('ESR' = "0" or 'ESR' = "1")

tmj_R15_AFP
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('discomfort' = "1" or 'dullache' = "1" or 'throbbing' = "1")
and
not('openingCAF' = "1" or 'yawningCAF' = "1" or 'talkingCAF' =
= "1") or 'bitingCAF' = "1" or 'hardfoodCAF' = "1" or
'chewingCAF' = "1") and
not('ArteryTender' = "1")

tmj_R16_PostHerpNeug
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
not('discomfort' = "1" or 'dullache' = "1" or 'throbbing' =
"1") and
('sharp' = "1" or 'electric_liked' = "1") and
('touchingCAF' = "1" or 'triggerpointASS' = "1") and
('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' = "1" or
'burning' = "1") and
('historyvesiclePRPPMH' = "1")

tmj_R17_hybAFP/TN
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "*pain" or
'OtherComplaint2' = "pain") and
not('discomfort' = "1" or 'dullache' = "1" or 'throbbing' =
"1") and
('sharp' = "1" or 'electric_liked' = "1") and
('touchingCAF' = "1" or 'triggerpointASS' = "1") and
('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' = "1" or
'burning' = "1") and
not('historyvesiclePRPPMH' = "1") and
('norm_CN_finding' = "1")

tmj_R18_intcraTu_Aneu_NasoCA_MS
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
not('discomfort' = "1" or 'dullache' = "1" or 'throbbing' =
"1") and
('sharp' = "1" or 'electric_liked' = "1") and
('touchingCAF' = "1" or 'triggerpointASS' = "1") and
('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' or
'burning' = "1") and
not('historyvesiclePRPPMH' = "1") and
not('norm_CN_finding' = "1")

tmj_R19_TN
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and

```



```

    not('discomfort' = "1" or 'dullache' = "1" or 'throbbing' =
"1") and
('sharp' = "1" or 'electric_liked' = "1") and
(touchingCAF' = "1" or 'triggerpointASS' = "1") and
    not('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' = "1"
or 'burning' = "1")

tmj_R20_FAM
('TMJ' = 'I' or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
    not('discomfort' = "1" or 'dullache' = "1" or 'throbbing' "1")
and
('sharp' = "1" or 'electric_liked' = "1") and
    ot('touchingCAF' = "1" or 'triggerpointASS' = "1") and
('openingCAF' = "1" or 'yawningCAF' = "1" or 'bitingCAF' = "1"
or 'chewingCAF' = "1" or 'hardfoodCAF' = "1") and
    (not('tender_TMJ_E' = "nil") or 'tender_muscleE' = "1") and
    not('ErosionXray' = "1" or 'OsteophyteXray' = "1")

tmj_R21_OA
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
    not('discomfort' = "1" or 'dullache' = "1" or 'throbbing' =
"1") and
('sharp' = "1" or 'electric-liked' = "1") and
    not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
('openingCAF' = "1" or 'yawningCAF' = "1" or 'bitingCAF' = "1"
or 'chewingCAF' = "1" or 'hardfoodCAF' = "1") and
    (not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
('ErosionXray' = "1" or 'OsteophyteXray' = "1") and
('rheumatoid factor' = "0" or 'rheumatoid factor' = "1")

tmj_R22_RhA
('TMJ' = "1" or 'Ear' = "1" or 'Temple' = "1") and
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
    not('discomfort' = "1" or 'dullache' = "1" or 'throbbing' =
"1") and
('sharp' = "1" or 'electric-liked' = "1") and
    not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
('openingCAF' = "1" or 'yawninglCAF' = "1" or 'bitingCAF' = "1"
or 'chewingCAF' = "1" or 'hardfoodCAF' = "1") and
    (not('tender_TMJ_E' = "nil" or 'tender_muscleE' = "1") and
('ErosionXray' = "1" or 'OsteophyteXray' = "1") and
    not('rheumatoid factor' = "0" or 'rheumatoid factor' = "1")

```

There are many rules for the same diagnosis, therefore, the diagnosis of a particular pain can be derived from several rules. The following paragraph is summary of those rules.

```

tmj_DDWR
    'tmj_R1_DDWR' = "T"

tmj_OAthesis
    'tmj_R2_OAthesis' = "T"

tmj_FAM
    'tmj_R3_FAM' = "T" or
    'tmj_R6_FAM' = "T" or

```

```

'tmj_R7_FAM' = "T" or
'tmj_R20_FAM' = "T"

tmj_OA
'tmj_R4_OA' = "T" or
'tmj_R8_OA' = "T" or
'tmj_R21_OA' = "T"

tmj_RhA
'tmj_R5_RhA' = "T" or
'tmj_R9_RhA' = "T" or
'tmj_R22_RhA' = "T"

tmj_GiArthritis
'tmj_R10_GiArthritis' = "T" or
'tmj_R13_GiArthritis' = "T"

tmj_AFP
'tmj_R11_AFP' = "T" or
'tmj_R12_AFP' = "T" or
'tmj_R14_AFP' = "T" or
'tmj_R15_AFP' = "T"

tmj_PostHerpNeug
'tmj_R16_PostHerpNeug' = "T"

tmj_HybAFP/TN
'tmj_R17_HybAFP/TN' = "T"

tmj_intcraTu_Aneu_NasoCA_MS
'tmj_R18_intcraTu_Aneu_NasoCA_MS' = "T"

tmj_TN
'tmj_R19_TN' = "T"

```

D.4. Diagnostic Rules for Pain in the Maxilla Region

```

mx_R1_PostHerpNeug
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
('touchingCAF' = "1" or 'triggerpointASS' = "1") and
('numbness' = "1" or 'numbnessASS' = "1" or 'tingling' = "1" or
'burning' = "1") and
('historyvesiclePRPPMH' = "1")

md_R2_hybAFP/TN
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
('touchingCAF' = "1" or 'triggerpointASS' = "1") and
('numbness' = "1" or 'numbnessASS' = "1" or 'tingling' = "1" or
'burning' = "1") and
not('historyvesiclePRPPMH' = "1") and
('norm_CN_finding' = "1")

md_R3_intcraTu_Aneu_NasoCA_MS
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and

```

```
( 'sharp' = "1" or 'electric_liked' = "1") and
( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
( 'numbness' = "1" or 'numbnessASS' = "1" or 'tingling' = "1" or
'burning' = "1") and
not( 'historyvesiclePRPPMH' = "1") and
not( 'norm_CN_finding' = "1")
```

mx_R4_TN

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Maxilla' = "1" and
( 'sharp' = "1" or 'electric_liked' = "1") and
( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'numbness' = "1" or 'numbnessASS' = "1" or 'tingling' = "1"
or
'burning' = "1")
```

mx_R5_FAM

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Maxilla' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
( 'openingCAF' = "1" or 'yawningCAF' = "1") and
not( 'tender_TMJ_E' = "nil") and
not( 'ErosionXray' = "1" or 'OsteophyteXray' = "1")
```

mx_R6_OA

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Maxilla' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
( 'openingCAF' = "1" or 'yawningCAF' = "1") and
not( 'tender_TMJ_E' = "nil") and
( 'ErosionXray' = "1" or 'OsteophyteXray' = "1") and
( 'rheumatoid factor' = "0" or 'rheumatoid factor' = "1")
```

mx_R7_RhA

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Maxilla' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
( 'openingCAF' = "1" or 'yawningCAF' = "1") and
not( 'tender_TMJ_E' = "nil") and
not( 'ErosionXray' = "1" or 'OsteophyteXray' = "1") and
not( 'rheumatoid factor' = "0" or 'rheumatoid factor' = "1")
```

mx_R8_Endo/Perio

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Maxilla' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
( 'Mobility' = "1" and 'Pocket' = "1")
```

mx_R9_revPP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Maxilla' = "1") and
```

```
( 'sharp' = "1" or 'electric_liked' = "1" and
  not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
  not('openingCAF' = "1" or 'yawningCAF' = "1") and
  ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
  ('bitingCAF' = "1" or 'chewingCAF' = "1" and
    not('Mobility' = "1" and 'Pocket' = "1" and
      ('Restoration' = "1" or 'Filling' = "1") and
      ('RecentRestoration' = "1") and
      not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
      ('ExposedPulp' = "1"))
```

mx_R10_PosResSen

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
  not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
  not('openingCAF' = "1" or 'yawningCAF' = "1") and
  ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
  ('bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
  ('Restoration' = "1" or 'Filling' = "1") and
  ('RecentRestoration' = "1") and
  not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
  not('ExposedPulp' = "1")
```

mx_R11_revPP_CrTh

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
  not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
  not('openingCAF' = "1" or 'yawningCAF' = "1") and
  ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
  ('bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
  ('Restoration' = "1" or 'Filling' = "1") and
  not('RecentRestoration' = "1") and
  ('Caries' = "1" or 'FractureExploration' = "1")
```

mx_R12_CrTh

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
  not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
  not('openingCAF' = "1" or 'yawningCAF' = "1") and
  ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
  ('bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
  ('Restoration' = "1" or 'Filling' = "1") and
  not('RecentRestoration' = "1") and
  not('Caries' = "1" or 'FractureExploration' = "1") and
  not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
  ('ReboundPain' = "1" )
```

mx_R13_AO

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
  not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
  not('openingCAF' = "1" or 'yawningCAF' = "1") and
  ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
```

```
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
( 'Restoration' = "1" or 'Filling' = "1" ) and
not( 'RecentRestoration' = "1" ) and
not( 'Caries' = "1" or 'FractureExploration' = "1" ) and
not( 'EncroachXray' = "1" or 'PDLXray' = "1" or 'RadiolucentXray'
= "1" ) and
not( 'ReboundPain' = "1" )
```

mx_R14_revPP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Maxilla' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
not( 'Restoration' = "1" or 'Filling' = "1" ) and
( 'Caries' = "1" or 'Cavity' = "1" )
```

mx_R15_PTrevPP/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Maxilla' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
not( 'Restoration' = "1" or 'Filling' = "1" ) and
not( 'Caries' = "1" or 'Cavity' = "1" ) and
( 'FractureClinic' = "1" )
```

mx_R16_CrTh

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Maxilla' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
not( 'Restoration' = "1" or 'Filling' = "1" ) and
not( 'Caries' = "1" or 'Cavity' = "1" ) and
not( 'FractureClinic' = "1" ) and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
( 'ReboundPain' = "1" )
```

mx_R17_AO

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Maxilla' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
not( 'Restoration' = "1" or 'Filling' = "1" ) and
not( 'Caries' = "1" or 'Cavity' = "1" ) and
```

```

not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ReboundPain' = "1" )

mx_R18_refPain_AFP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

mx_R19_intOssPath
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

mx_R20_revPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

mx_R21_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
('ReboundPain' = "1")

mx_R22_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and

```

```
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
( 'TenderPercussion' = "1" ) and
( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' "1" ) and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
not( 'ExposedPulp' = "1" ) and
not( 'ReboundPain' = "1" )
```

mx_R23_PTrevPP/AP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Maxilla' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not( 'openingCAF' "1" or 'yawningCAF' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
( 'TenderPercussion' = "1" ) and
not( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1" ) and
( 'FractureClinic' = "1" ) and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1" )
```

mx_R24_CrTh

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Maxilla' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
( 'TenderPercussion' = "1" ) and
not( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1" ) and
not( 'FractureClinic' = "1" ) and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1" and
' ReboundPain' = "1" )
```

mx_R25_AO

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Maxilla' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
not( 'bitingCAF' = "1" or 'chewingCAF' "1" ) and
( 'TenderPercussion' = "1" ) and
not( 'Restoration' = "1" or 'Filling' = "1" or, 'Caries' = "1"
or ' Cavity' = "1" ) and
not( 'FractureClinic' = "1" ) and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
not( 'ReboundPain' = "1" )
```

mx_R26_revPP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Maxilla' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
```



```

not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

```

mx_R27_PosResSen

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1")

```

mx_R28_revPP_CrTh

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('Caries' = "1" or 'FractureExploration' = "1")

```

mx_R29_CrTh

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ReboundPain' = "1")

```

mx_R30_AO

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and

```



```

    not('ReboundPain' = "1")

mx_R31_revPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
 'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
('Caries' = "1")

mx_R32_DenSen
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
 'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1") and
('GingivalRecession' = "1" or 'Cavity' = "1") and
('BriefSen' = "1")

mx_R33_revPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
 'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1") and
('GingivalRecession' = "1" or 'Cavity' = "1") and
not('BriefSen' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1")

mx_R34_AO_refPain
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
 'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1") and
not('GingivalRecession' = "1" or 'Cavity' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1")

mx_R35_PosResSen
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
 'OtherComplaint2' = "pain") and

```

```

('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1")

mx_R36_revPP_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('Caries' = "1" or 'FractureExploration' = "1")

mx_R37_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1")
('ReboundPain' = "1")

mx_R38_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1") and
not('ReboundPain' = "1")

mx_R39_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and

```

```

('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('EPTnegative' = "1")

mx_R40_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

mx_R41_AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
('Hyperocclusion' = "1")

mx_R42_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Hyperocclusion' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1") and
('ReboundPain' = "1")

mx_R43_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Hyperocclusion' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1") and
not('ReboundPain' = "1")

mx_R44_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or

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```

'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Hyperocclusion' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('EPTnegative' = "1")

mx_R45_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Hyperocclusion' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

mx_R46_Endo/Perio
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Mobility' = "1" and 'Pocket' = "1")

mx_R47_irrPP/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1" and
('dullache' = "1" or 'throbbing' = "1" ) and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

mx_R48_CrTh/irrPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1" and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
('ReboundPain' = "1")

```

mx_R49_AO

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1" and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
not('ReboundPain' = "1")

```

mx_R50_irrPP/AAP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1" ) and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

```

mx_R51_PTirrPP/AAP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
('FractureClinic' = "1")

```

mx_R52_CrTh/irrPP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('FractureClinic' = "1") am
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ReboundPain' = "1")

```

mx_R53_AO

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and

```

```

not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ReboundPain' = "1")

```

mx_R54_PtirrPP/AAP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('FractureClinic' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

```

mx_R55_FAM

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('openingCAF' = "1" or 'yawningCAF' = "1")

```

mx_R56_AFP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('bendingheadCAF' = "1") and
not('FluidLevelXray' = "1" or 'RadiopaqueXray' = "1" or
'DiffOpaqueXray' = "1" or 'BoneDestructXray' = "1" or
'BoneExpansionXray' = "1")

```

mx_R57_Sinus

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1" ) and
('bendingheadCAF' = "1") and
('FluidLevelXray' = "1")

```

mx_R58_FMN

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and

```

```

not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1" ) and
not('bendingheadCAF' = "1") and
'nasalstiffness/obstructionASS' = "1" or 'Epiphora' = "1") and
not('FluidLevelXray' = "1" or 'RadiopaqueXray' = "1" or
DiffOpaqueXray' = "1" or 'BoneDestructXray' = "1" or
'BoneExpansionXray' = "1")

```

mx_R59_Sinus

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1" ) and
not('bendingheadCAF' = "1") and
('nasalstiffness/obstructionASS' = "1" or 'Epiphora' = "1") and
('FluidLevelXray' = "1")

```

mx_R60_OdontCyst/Tu_CA

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1" ) and
not('bendingheadCAF' = "1" and
('nasalstiffness/obstructionASS' = "1" or 'Epiphora' = "1" and
('RadiopaqueXray' = "1" or 'DiffOpaqueXray' = "1" or
'BoneDestructXray' = "1" or 'BoneExpansionXray' = "1")

```

mx_R61_FMN

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1" ) and
not('bendingheadCAF' = "1") and
not('nasalstiffness/obstructionASS' = "1" or 'Epiphora' = "1")

```

and

```

not('RadiopaqueXray' = "1" or 'FluidLevelXray' = "1" or
'DiffOpaqueXray' = "1" or 'BoneDestructXray' = "1" or
'BoneExpansionXray' = "1") and
('Sleep' = "wake up")

```

mx_R62_AFP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1" ) and
not('bendingheadCAF' = "1") and

```



```

    not('nasalstiffness/obstructionASS' = "1" or 'Epiphora' = "1")
and
    not('RadiopaqueXray' = "1" or 'FluidLevelXray' = "1" or
'DiffOpaqueXray' = "1" or 'BoneDestructXray' = "1" or
'BoneExpansionXray' = "1") and
    not('Sleep' = "wake up")

mx_R63_OdonCyst/Tu_CA
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
    ('Maxilla' = "1") and
    not('sharp' = "1" or 'electric_liked' = "1") and
    ('dullache' = "1" or 'throbbing' = "1") and
    not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
    not('bitingCAF' = "1" or 'chewingCAF' = "1" and
    not('openingCAF' = "1" or 'yawningCAF' = "1" ) and
    not('bendingheadCAF' = "1") and
    not('nesalstiffness/obstructionASS' = "1" or 'Epiphora' = "1")
and
    ('RadiopaqueXrag' = "1" or 'DiffOpaqueXray' = "1" or
BoneDestructXray' = "1" or 'BoneExpansionXray' = "1")

mx_R64_irrPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
    ('Maxilla' = "1") and
    not('sharp' = "1" or 'electric_liked' = "1") and
    ('dullache' = "1" or 'throbbing' = "1") and
    ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
    not('bitingCAF' = "1" or 'chewingCAF' = "1") and
    ('TenderPercussion' = "1") and
    ('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
    not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
    ('ExposedPulp' = "1")

mx_R65_CrTh/irrPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
    ('Maxilla' = "1") and
    not('sharp' = "1" or 'electric-liked' = "1") and
    ('dullache' = "1" or 'throbbing' = "1") and
    ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
    not('bitingCAF' = "1" or 'chewingCAF' = "1") and
    ('TenderPercussion' = "1") and
    ('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
    not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
    not('ExposedPulp' = "1") and
    ('ReboundPain' = "1")

mx_R66_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
    ('Maxilla' = "1") and
    not('sharp' = "1" or 'electric-liked' = "1") and
    ('dullache' = "1" or 'throbbing' = "1") and
    ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" and
    not('bitingCAF' = "1" or 'chewingCAF' = "1") and
    ('TenderPercussion' = "1") and
    ('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' =
"1") and
    not('PDLXray' = "1" or 'RadiolucentXray' = "1") and

```



```
not('ExposedPulp' = "1") and
not('ReboundPain' = "1")
```

mx_R67_irrPP/AP

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")
```

mx_R68_PTirrPP/AP

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1" and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
('FractureClinic' = "1")
```

mx_R69_CrTh/irrPP

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1" and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ReboundPain' = "1")
```

mx_R70_AO

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ReboundPain' = "1")
```

mx_R71_PTirrPP/AP

```
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
```

```

('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('FractureClinic' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

mx_R72_Perio
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Mobility' = "1" and 'Pocket' = "1")

mx_R73_AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1")

mx_R74_Pnec/AAP_FxEndoTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('Caries' = "1" or 'FractureExploration' = "1")

mx_R75_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1")

mx_R76_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and

```

```

('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('EPTnegative' = "1")

mx_R77_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

mx_R78_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
('Caries' = "1" or 'Cavity' = "1") and
('ExposedPulp' = "1") and
('EPTnegative' = "1")

mx_R79_PTnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
('FractureClinic' = "1")

mx_R80_Pericoro
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
('PERupt' = "1")

```

mx_R81_FAM

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PERupt' = "1") and
not('tender_TMJ_E' = "nil") or 'tender_muscleE' = "1")

```

mx_R82_Sialolith

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PERupt' = "1") and
not(not('tender_TMJ_E' = "nil") or 'tender_muscleE' = "1") and
('ParotidTender' = "1")

```

mx_R83_GiArthritis

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PERupt' = "1") and
not(not('tender_TMJ_E' = "nil") or 'tender_muscleE' = "1") and
not('ParotidTender' = "1") and
('ArteryTender' = "1")

```

mx_R84_AO_AFP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1") or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PERupt' = "1") and
not(not('tender_TMJ_E' = "nil") or 'tender_muscleE' = "1") and
not('ParotidTender' = "1") and

```

```

not('ArteryTender' = "1") and
not('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

mx_R85_intOssPath
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Maxilla' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = *'1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PErupt' = "1") and
not(not('tender_TMJ_E' = "nil") or 'tender_muscleE' = "1") and
not('ParotidTender' = "1") and
not('ArteryTender' = "1") and
('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

```

There are many rules for the same diagnosis, therefore, the diagnosis of a particular pain can be derived from several rules. The following paragraph is summary of those rules.

```

mx_PostHerpNeug
  'mx_R1_PostHerpNeug' = "T"

mx_hybAFP/TN
  'mx_R2_hybAFP/TN' = "T"

mx_intcraTu_NasoCA_MS_Aneu
  'mx_R3_intcraTu_NasoCA_MS_Aneu' = "T"

mx_TN
  'mx_R4_TN' = "T"

mx_FAM
  'mx_R5_FAM' = "T" or
  'mx_R55_FAM' = "T" or
  'mx_R81_FAM' = "T"

mx_OA
  'mx_R6_OA' = "T"

mx_RhA
  'mx_R7_RhA' = "T"

mx_EndoPerio
  'mx_R8_Endo/Perio' = "T" or
  'mx_R46_EndoPerio' = "T"

mx_revPP
  'mx_R9_revPP' = "T" or
  'mx_R14_revPP' = "T" or
  'mx_R26_revPP' = "T" or
  'mx_R31_revPP' = "T" or
  'mx_R33_revPP' = "T"

mx_PosResSen
  'mx_R10_PosResSen' = "T" or

```

```

'mx_R27_PosResSen' = "T" or
'mx_R35_PosResSen' = "T"

mx_revPP_CrTh
'mx_R11_revPP_CrTh' = "T" or
'mx_R28_revPP_CrTh' = "T" or
'mx_R36_revPP_CrTh' = "T"

mx_CrTh
'mx_R12_CrTh' = "T" or
'mx_R16_CrTh' = "T" or
'mx_R21_CrTh' = "T" or
'mx_R24_CrTh' = "T" or
'mx_R29_CrTh' = "T" or
'mx_R37_CrTh' = "T" or
'mx_R42_CrTh' = "T"

mx_CrTh/irrPP
'mx_R48_CrTh/irrPP' = "T" or
'mx_R52_CrTh/irrPP' = "T" or
'mx_R65_CrTh/irrPP' = "T" or
'mx_R69_CrTh/irrPP' = "T"

mx_AO
'mx_R13_AO' = "T" or
'mx_R17_AO' = "T" or
'mx_R22_AO' = "T" or
'mx_R25_AO' = "T" or
'mx_R30_AO' = "T" or
'mx_R38_AO' = "T" or
'mx_R43_AO' = "T" or
'mx_R49_AO' = "T" or
'mx_R53_AO' = "T" or
'mx_R66_AO' = "T" or
'mx_R70_AO' = "T" or
'mx_R75_AO' = "T"

mx_PTrevPP/AAP
'mx_R15_PTrevPP/AAP' = "T"

mx_refPain_AFP
'mx_R18_refPain_AFP' = "T"

mx_intOssPath
'mx_R19_intOssPath' = "T" or
'mx_R85_intOssPath' = "T"

mx_revPP/AP
'mx_R20_revPP/AP' = "T"

mx_PTrevPP/AP
'mx_R23_PTrevPP/AP' = "T"

mx_DenSen
'mx_R32_DenSen' = "T"

mx_AO_refPain
'mx_R34_DenSen' = "T"

mx_Pnec/AAP
'mx_R39_Pnec/AAP' = "T" or
'mx_R40_Pnec/AAP' = "T" or
'mx_R44_Pnec/AAP' = "T" or
'mx_R45_Pnec/AAP' = "T" or

```

```

'mx_R76_Pnec/AAP' = "T" or
'mx_R77_Pnec/AAP' = "T" or
'mx_R78_Pnec/AAP' = "T"

mx_PTnec/AAP
'mx_R79_PTnec/AAP' = "T"

mx_AAP
'mx_R41_AAP' = "T" or
'mx_R73_AAP' = "T"

mx_irrPP/AAP
'mx_R47_irrPP/AAP' = "T" or
'mx_R50_irrPP/AAP' = "T"

mx_AFP
'mx_R56_AFP' = "T" or
'mx_R62_AFP' = "T"

mx_Sinus
'mx_R57_Sinus' = "T" or
'mx_R59_Sinus' = "T"

mx_FMN
'mx_R58_FMN' = "T" or
'mx_R61_FMN' = "T"

mx_OdonCyst/Tu_CA
'mx_R60_OdonCyst/Tu_CA' = "T" or
'mx_R63_OdonCyst/Tu_CA' = "T"

mx_irrPP/AP
'mx_R64_irrPP/AP' = "T" or
'mx_R67_irrPP/AP' = "T"

mx_PTirrPP/AP
'mx_R68_PTirrPP/AP' = "T" or
'mx_R71_PTirrPP/AP' = "T"

mx_Perio
'mx_R72_Perio' = "T"

mx_Pnec/AAP_FxEndoTh
'mx_R74_Pnec/AAP_FxEndoTh' = "T"

mx_Pericoro
'mx_R80_Pericoro' = "T"

mx_Sialolith
'mx_R82_Sialolith' = "T"

mx_GiArtitis
'mx_R83_GiArtitis' = "T"

mx_AO_AFP
'mx_R84_AO_AFP' = "T"

```

D. 5. Diagnostic Rules for Pain in the Mandibular Region

```

md_R1_PostHerpNeug
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
 'OtherComplaint2' = "pain") and

```



```

('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
('touchCAF' = "1" or 'triggerpointASS' = "1") and
('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' = "1" or
'burning' = "1") and
('historyvesiclePRPPMH' = "1")

md_R2_hybAFP/TN
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
('touchCAF' = "1" or 'triggerpointASS' = "1") and
('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' or
'burning' = "1") and
not('historyvesiclePRPPMH' = "1") and
('norm_CN_finding' = "1")

md_R3_intcraTu_Aneu_NasoCA_MS
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
('touchCAF' = "1" or 'triggerpointASS' = "1") and
('numbnessASS' = "1" or 'numbness' = "1" or 'tingling.' = "1" or
'burning' = "1") and
not('historyvesiclePRPPMH' = "1") and
not('norm_CN_finding' = "1")

md_R4_TN
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
('touchCAF' = "1" or 'triggerpointASS' = "1") and
not('numbnessASS' = "1" or 'numbness' = "1" or 'tingling' = "1"
or 'burning' = "1" )

md_R5_FAM
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchCAF' = "1" or 'triggerpointASS' = "1") and
('openingCAF' = "1" or 'yawningCAF' = "1") and
not('tender_TMJ_E' = "nil") and
not('ErosionXray' = "1" or 'OsteophyteXray' = "1")

md_R6_OA
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchCAF' = "1" or 'triggerpointASS' = "1") and
('openingCAF' = "1" or 'yawningCAF' = "1") and
not('tender_TMJ_E' = "nil") and
('ErosionXray' = "1" or 'OsteophyteXray' = "1") and
('rheumatoid factor' = "0" or 'rheumatoid factor' = "1")

md_R7_RhA
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and

```



```

not('touchCAF' = "1" or 'triggerpointASS' = "1") and
('openingCAF' = "1" or 'yawningCAF' = "1") and
not('tender_TMJ_E' = "nil") and
('ErosionXray' = "1" or 'OsteophyteXray' = "1") and
not('rheumatoid factor' = "0" or 'rheumatoid factor' = "1")

md_R8_Endo/Perio
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Mobility' = "1" and 'Pocket' = "1")

md_R9_revPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

md_R10_PosResSen
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1")

md_R11_revPP_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('Caries' = "1" or 'FractureExploration' = "1")

md_R12_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and

```

```
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
not( 'Mobility' = "1" and 'Pocket' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
not( 'RecentRestoration' = "1") and
not( 'Caries' = "1" or 'FractureExploration' = "1") and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1") and
( 'ReboundPain' = "1")
```

md_R13_AO

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
not( 'Mobility' = "1" and 'Pocket' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
not( 'RecentRestoration' = "1") and
not( 'Caries' = "1" or 'FractureExploration' = "1") and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1") and
not( 'ReboundPain' = "1")
```

md_R14_revPP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
not( 'Mobility' = "1" and 'Pocket' = "1") and
not( 'Restoration' = "1" or 'Filling' = "1") and
( 'Caries' = "1" or 'Cavity' = "1")
```

md_R15_PtrevPP/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
not( 'Mobility' = "1" and 'Pocket' = "1") and
not( 'Restoration' = "1" or 'Filling' = "1") and
not( 'Caries' = "1" or 'Cavity' = "1") and
( 'Fractureclinic' = "1")
```

md_R16_CrTh

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
```

```

('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('EncroachXray' = "1" or 'PDLXray' = "1" or
'RadiolucentXray'
= "1") and
('ReboundPain' = "1")

md_R17_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('EncroachXray' = "1" or 'PDLXray' = "1" or
'RadiolucentXray' = "1") and
not('ReboundPain' = "1")

md_R18_refPain_AFP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or '
OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

md_R19_intOssPath
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

md_R20_revPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1")
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

```

md_R21_CrTh

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
( 'TenderPercussion' = "1") and
( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1") and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1") and
not( 'ExposedPulp' = "1") and
( 'ReboundPain' = "1")
```

md_R22_AO

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = -1" or 'coldfood/drinkCAF' = "1") and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
( 'TenderPercussion' = "1") and
( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1") and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1") and
not( 'ExposedPulp' = "1") and
not( 'ReboundPain' = "1")
```

md_R23_PtrevPP/AP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
( 'TenderPercussion' = "1") and
not( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1") and
( 'FractureClinic' = "1") and
( 'PDLXray' = "1" or 'RadiolucentXray' = "1")
```

md_R24_CrTh

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
( 'TenderPercussion' = "1") and
not( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1") and
not( 'FractureClinic' = "1") and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1") and
( 'ReboundPain' = "1")
```

md_R25_AO

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
( 'TenderPercussion' = "1") and
not( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
Cavity' = "1") and
not( 'FractureClinic' = "1") and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1") and
not( 'ReboundPain' = "1")
```

md_R26_revPP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
not( 'TenderPercussion' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
( 'RecentRestoration' = "1") and not( 'PDLXray' = "1" or
'RadiolucentXray' = "1") and
( 'ExposedPulp' = "1")
```

md_R27_PosResSen

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
not( 'TenderPercussion' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
( 'RecentRestoration' = "1") and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1") and
not( 'ExposedPulp' = "1")
```

md_R28_revPP_CrTh

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1" and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
not( 'TenderPercussion' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
not( 'RecentRestoration' = "1") and
( Caries = "1" or 'FractureExploration' = "1")
```

md_R29_CrTh

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
```

```

not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ReboundPain' = "1")

```

md_R30_AO

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ReboundPain' = "1")

```

md_R31_revPP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" ) and
('Caries' = "1")

```

md_R32_DenSen

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1") and
('Cavity' = "1" or 'GingivalRecession' = "1") and
('BriefSen' = "1")

```

md_R33_revPP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and

```

```

not('Caries' = "1") and
('Cavity' = "1" or 'GingivalRecession' = "1") and
not('BriefSen' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1")

md_R34_AO_refPain
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1" and
not('openingCAF' = "1" or 'yawningCAF' = "1" and
('hotfood/drinkCAF' = "V" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1") and
not('Cavity' = "1" or 'GingivalRecession' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1")

md_R35_PosResSen
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1" )and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('EncroachXray' = "1" or 'PDLXray' = "1" or 'RadiolucentXray'
= "1")

md_R36_revPP_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('Caries' = "1" or 'FractureExploration' = "1")

md_R37_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('touchingCAF' = "1" or 'triggerpointASS' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1") and
('ReboundPain' = "1")

md_R38_AO

```



```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
not( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
not( 'RecentRestoration' = "1") and
not( 'Caries' = "1" or 'FractureExploration' = "1") and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1") and
not( 'EPTnegative' = "1") and
not( 'ReboundPain' = "1")
```

md_R39_Pnec/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
not( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
not( 'RecentRestoration' = "1") and
not( 'Caries' = "1" or 'FractureExploration' = "1") and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1") and
( 'EPTnegative' = "1")
```

md_R40_Pnec/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
not( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
not( 'RecentRestoration' = "1") and
not( 'Caries' = "1" or 'FractureExploration' = "1") and
( 'PDLXray' = "1" or 'RadiolucentXray' = "1")
```

md_R41_AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
not( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
not( 'Restoration' = "1" or 'Filling' = "1") and
( 'Hyperocclusion' = "1")
```

md_R42_CrTh

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
( 'sharp' = "1" or 'electric_liked' = "1") and
not( 'touchingCAF' = "1" or 'triggerpointASS' = "1") and
not( 'openingCAF' = "1" or 'yawningCAF' = "1") and
not( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
```



```
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not ( 'Restoration' = "1" or 'Filling' = "1" ) and
not ( 'Hyperocclusion' = "1" ) and
not ( 'PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
not ( 'EPTnegative' = "1" ) and
( 'ReboundPain' = "1" )
```

md_R43_AO

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Mandible' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not ( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not ( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
not ( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not ( 'Restoration' = "1" or 'Filling' = "1" ) and
not ( 'Hyperocclusion' = "1" ) and
not ( 'PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
not ( 'EPTnegative' = "1" ) and
not ( 'ReboundPain' = "1" )
```

md_R44_Pnec/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Mandible' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not ( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not ( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
not ( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not ( 'Restoration' = "1" or 'Filling' = "1" ) and
not ( 'Hyperocclusion' = "1" ) and
not ( 'PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
( 'EPTnegative' = "1" )
```

md_R45_Pnec/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Mandible' = "1" ) and
( 'sharp' = "1" or 'electric_liked' = "1" ) and
not ( 'touchingCAF' = "1" or 'triggerpointASS' = "1" ) and
not ( 'openingCAF' = "1" or 'yawningCAF' = "1" ) and
not ( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not ( 'Restoration' = "1" or 'Filling' = "1" ) and
not ( 'Hyperocclusion' = "1" ) and
( 'PDLXray' = "1" or 'RadiolucentXray' = "1" )
```

md_R46_EndoPerio

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Mandible' = "1" ) and
not ( 'sharp' = "1" or 'electric_liked' = "1" ) and
( 'dullache' = "1" or 'throbbing' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
( 'Mobility' = "1" and 'Pocket' = "1" )
```

md_R47_irrPP/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Mandible' = "1" ) and
not ( 'sharp' = "1" or 'electric_liked' = "1" ) and
```

```
( 'dullache' = "1" or 'throbbing' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1" ) and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
( 'ExposedPulp' = "1" )
```

md_R48_CrTh/irrPP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Mandible' = "1" ) and
not( 'sharp' = "1" or 'electric_liked' = "1" ) and
( 'dullache' = "1" or 'throbbing' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1" ) and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
not( 'ExposedPulp' = "1" ) and
( 'ReboundPain' = "1" )
```

md_R49_AO

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Mandible' = "1" ) and
not( 'sharp' = "1" or 'electric_liked' = "1" ) and
( 'dullache' = "1" or 'throbbing' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1" ) and
not( 'PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
not( 'ExposedPulp' = "1" ) and
not( 'ReboundPain' = "1" )
```

md_R50_irrPP/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Mandible' = "1" ) and
not( 'sharp' = "1" or 'electric_liked' = "1" ) and
( 'dullache' = "1" or 'throbbing' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1" ) and
( 'PDLXray' = "1" or 'RadiolucentXray' = "1" )
```

md_R51_PTirrPP/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
( 'Mandible' = "1" ) and
not( 'sharp' = "1" or 'electric_liked' = "1" ) and
( 'dullache' = "1" or 'throbbing' = "1" ) and
( 'hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
( 'bitingCAF' = "1" or 'chewingCAF' = "1" ) and
not( 'Mobility' = "1" and 'Pocket' = "1" ) and
not( 'Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
' Cavity' = "1" ) and
( 'FractureClinic' = "1" )
```

```

md_R52_CrTh/irrPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ReboundPain' = "1")

md_R53_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1") or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ReboundPain' = "1")

md_R54_PTirrPP/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1") or
'Cavity' = "1") and
not('FractureClinic' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

md_R55_FAM
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('openingCAF' = "1" or 'yawningCAF' = "1")

md_R56_AFP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' "1" or chewingCAF "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and

```

```

not('RadiolucentXray' = "1") or not('RadiopaqueXray' = "1")

md_R57_Chroste_Cyst_IntOssTu
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('openingCAF' = "1" or 'yawningCAF' = "1") and
('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

md_R58_irrPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

md_R59_CrTh/irrPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
('ReboundPain' = "1")

md_R60_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
'Cavity' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
not('ReboundPain' = "1")

md_R61_irrPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and

```

```

    not('bitingCAF' = "1" or 'chewingCAF' = "1") and
    ('TenderPercussion' = "1") and
    ('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
    'Cavity' = "1") and
    ('PDLXray' = "1" or 'RadiolucentXray' = "1")

md_R62_PTirrPP/AP
    ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
    'OtherComplaint2' = "pain") and
    ('Mandible' = "1") and
    not('sharp' = "1" or 'electric_liked' = "1") and
    ('dullache' = "1" or 'throbbing' = "1") and
    ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
    not('bitingCAF' = "1" or 'chewingCAF' = "1") and
    ('TenderPercussion' = "1") and
    not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
    'Cavity' = "1") and
    ('FractureClinic' = "1")

md_R63_CrTh/irrPP
    ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
    'OtherComplaint2' = "pain") and
    ('Mandible' = "1") and
    not('sharp' = "1" or 'electric_liked' = "1") and
    ('dullache' = "1" or 'throbbing' = "1") and
    ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
    not('bitingCAF' = "1" or 'chewingCAF' = "1") and
    ('TenderPercussion' = "1") and
    not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
    'Cavity' = "1") and
    not('FractureClinic' = "1") and
    not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
    ('ReboundPain' = "1")

md_R64_AO
    ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
    'OtherComplaint2' = "pain") and
    ('Mandible' = "1") and
    not('sharp' = "1" or 'electric_liked' = "1") and
    ('dullache' = "1" or 'throbbing' = "1") and
    ('hotfood/drinkCAF' = "V" or 'coldfood/drinkCAF' = "1") and
    not('bitingCAF' = "1" or 'chewingCAF' = "1") and
    ('TenderPercussion' = "1") and
    not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
    'Cavity' = "1") and
    not('FractureClinic' = "1") and
    not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
    not('ReboundPain' = "1")

md_R65_PtirrPP/AP
    ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
    'OtherComplaint2' = "pain") and
    ('Mandible' = "1") and
    not('sharp' = "1" or 'electric_liked' = "1") and
    ('dullache' = "1" or 'throbbing' = "1") and
    ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
    not('bitingCAF' = "1" or 'chewingCAF' = "1") and
    ('TenderPercussion' = "1") and
    not('Restoration' = "1" or 'Filling' = "1" or 'Caries' = "1" or
    'Cavity' = "1") and
    not('FractureClinic' = "1") and
    not('PDLXray' = "1" or 'RadiolucentXray' = "1")

```

```

md_R66_MalIntOssTu
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
  ('Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
  ('dullache' = "1" or 'throbbing' = "1") and
  not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
  ('bitingCAF' = "1" or 'chewingCAF' = "1") and
  ('NumbLip' = "1") and
  ('RadiolucentXray' = "1")

md_R67_Perio
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
  ('Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
  ('dullache' = "1" or 'throbbing' = "1") and
  not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
  ('bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('NumbLip' = "1") and
  ('Mobility' = "1" and 'Pocket' = "1")

md_R68_AAP
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
  ('Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
  ('dullache' = "1" or 'throbbing' = "1") and
  not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
  ('bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('NumbLip' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
  ('Restoration' = "1" or 'Filling' = "1") and
  ('RecentRestoration' = "1")

md_R69_Pnec/AAP_FxEndoTh
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
  ('Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
  ('dullache' = "1" or 'throbbing' = "1") and
  not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
  ('bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('NumbLip' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
  ('Restoration' = "1" or 'Filling' = "1") and
  not('RecentRestoration' = "1") and
  ('Caries' = "1" or 'FractureExploration' = "1")

md_R70_AO
  ('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
  ('Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
  ('dullache' = "1" or 'throbbing' = "1") and
  not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
  ('bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('NumbLip' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
  ('Restoration' = "1" or 'Filling' = "1") and
  not('RecentRestoration' = "1") and
  not('Caries' = "1" or 'FractureExploration' = "1") and
  not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
  not('EPTnegative' = "1")

```

md_R71_Pnec/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
( 'dullache' = "1" or 'throbbing' = "1") and
  not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('NumbLip' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
  not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
( 'EPTnegative' = "1")
```

md_R72_Pnec/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
( 'dullache' = "1" or 'throbbing' = "1") and
  not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('NumbLip' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
( 'Restoration' = "1" or 'Filling' = "1") and
  not('RecentRestoration' = "1") and
  not('Caries' = "1" or 'FractureExploration' = "1") and
( 'PDLXray' = "1" or 'RadiolucentXray' = "1")
```

md_R73_Pnec/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
( 'dullache' = "1" or 'throbbing' = "1") and
  not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('NumbLip' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
  not('Restoration' = "1" or 'Filling' = "1") and
( 'Caries' = "1" or 'Cavity' = "1") and
( 'ExposedPulp' = "1") and
( 'EPTnegative' = "1")
```

md_R74_Ptnec/AAP

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
( 'dullache' = "1" or 'throbbing' = "1") and
  not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
( 'bitingCAF' = "1" or 'chewingCAF' = "1") and
  not('NumbLip' = "1") and
  not('Mobility' = "1" and 'Pocket' = "1") and
  not('Restoration' = "1" or 'Filling' = "1") and
  not('Caries' = "1" or 'Cavity' = "1") and
( 'FractureClinic' = "1")
```

md_R75_Pericoro

```
( 'MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
  'OtherComplaint2' = "pain") and
( 'Mandible' = "1") and
  not('sharp' = "1" or 'electric_liked' = "1") and
```



```

('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('NumbLip' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
('PErupt' = "1")

```

md_R76_FAM

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('NumbLip' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PErupt' = "1") and
(not('tender_TMJ_E' = "nil") or ('tender_muscleE' = "1"))

```

md_R77_GiArthritis

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('NumbLip' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PErupt' = "1") and
not(not('tender_TMJ_E' = "nil") or ('tender_muscleE' = "1"))
and
('ArteryTender' = "1")

```

md_R77_AO_AFP

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('NumbLip' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PErupt' = "1") and
not(not('tender_TMJ_E' = "nil") or ('tender_muscleE' = "1")) and
not('ArteryTender' = "1") and
not('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

```

md_R79_ChroOsteo_Cyst_intOssTu


```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Mandible' = "1") and
not('sharp' = "1" or 'electric_liked' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('NumbLip' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('PErupt' = "1") and
not(not('tender_TMJ_E' = "nil" or (tender_muscleE' = "1")) and
not('ArteryTender' = "1") and
('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

```

There are many rules for the same diagnosis, therefore, the diagnosis of a particular pain can be derived from several rules. The following paragraph is summary of those rules.

```

md_PostHerpNeug
    'md_R1_PostHerpNeug' = "T"

md_hybAFP/TN
    'md_R2_hybAFP/TN' = "T"

md_intcraTu_NasoCA_MS_Aneu
    'md_R3_intraTu_NasoCA_MS_Aneu' = "T"

md_TN
    'md_R4_TN' = "T"

md_FAM
    'md_R5_FAM' = "T" or
    'md_R55_FAM' = "T" or
    'md_R76_FAM' = "T"

md_OA
    'md_R6_OA' = "T"

md_RhA
    'md_R7_RhA' = "T"

md_EndoPerio
    'md_R8_EndoPerio' = "T" or
    'md_R46_EndoPerio' = "T"

md_revPP
    'md_R9_revPP' = "T" or
    'md_R14_revPP' = "T" or
    'md_R26_revPP' = "T" or
    'md_R31_revPP' = "T" or
    'md_R33_revPP' = "T"

md_PosResSen
    'md_R10_PosResSen' = "T" or
    'md_R27_PosResSen' = "T" or
    'md_R35_PosResSen' = "T"

md_revPP_CrTh

```

```

'md_R11_revPP_CrTh' = "T" or
'md_R28_revPP_CrTh' = "T" or
'md_R36_revPP_CrTh' = "T"

md_CrTh
'md_R12_CrTh' = "T" or
'md_R16_CrTh' = "T" or
'md_R21_CrTh' = "T" or
'md_R24_CrTh' = "T" or
'md_R29_CrTh' = "T" or
'md_R37_CrTh' = "T" or
'md_R42_CrTh' = "T"

md_CrTh/irrPP
'md_R48_CrTh/irrPP' = "T" or
'md_R52_CrTh/irrPP' = "T" or
'md_R59_CrTh/irrPP' = "T" or
'md_R63_CrTh/irrPP' = "T"

md_AO
'md_R13_AO' = "T" or
'md_R17_AO' = "T" or
'md_R22_AO' = "T" or
'md_R25_AO' = "T" or
'md_R30_AO' = "T" or
'md_R38_AO' = "T" or
'md_R43_AO' = "T" or
'md_R49_AO' = "T" or
'md_R53_AO' = "T" or
'md_R60_AO' = "T" or
'md_R64_AO' = "T" or
'md_R70_AO' = "T"

md_PTrevPP/AAP
'md_R15_PTrevPP/AAP' = "T"

md_refPain_AFP
'md_R18_refPain_AFP' = "T"

md_intOssPath
'md_R19_intOssPath' = "T" or

md_revPP/AP
'md_R20_revPP/AP' = "T"

md_PTrevPP/AP
'md_R23_PTrevPP/AP' = "T"

md_DenSen
'md_R32_DenSen' = "T"

md_AO_refPain
'md_R34_DenSen' = "T"

md_Pnec/AAP
'md_R39_Pnec/AAP' = "T" or
'md_R40_Pnec/AAP' = "T" or
'md_R44_Pnec/AAP' = "T" or
'md_R45_Pnec/AAP' = "T" or
'md_R71_Pnec/AAP' = "T" or
'md_R72_Pnec/AAP' = "T" or
'md_R73_Pnec/AAP' = "T"

md_AAP

```

```

'md_R41_AAP' = "T" or
'md_R68_AAP' = "T"

md_irrPP/AAP
'md_R47_irrPP/AAP' = "T" or
'md_R50_irrPP/AAP' = "T"

md_PTirrPP/AAP
'md_R51_PTirrPP/AAP' = "T" or
'md_R54_PTirrPP/AAP' = "T"

md_AFP
'md_R56_AFP' = "T"

md_Chrosteo_Cyst_IntOssTu
'md_R57_Chrosteo_Cyst_IntOssTu' = "T" or
'md_R79_Chrosteo_Cyst_IntOssTu' = "T"

md_irrPP/AP
'md_R58_irrPP/AP' = "T" or
'md_R61_irrPP/AP' = "T"

md_PTirrPP/AP
'md_R62_PTirrPP/AP' = "T" or
'md_R65_PTirrPP/AP' = "T"

md_MalIntOssTu
'md_R66_MalIntOssTu' = "T"

md_Perio
'md_R67_Perio' = "T"

md_Pnec/AAP_FxEndoTh
'md_R69_Pnec/AAP_FxEndoTh' = "T"

md_PTnec/AAP
'md_R74_PTnec/AAP' = "T"

md_Pericoro
'md_R75_Pericoro' = "T"

md_GiArtitis
'md_R77_GiArtitis' = "T"

md_AO_AFP
'md_R78_AO_AFP' = "T"

```

D.6. Diagnostic Rules for Pain in the Teeth and Alveolar Region

```

th_R1_revPP/Perio
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Mobility' = "1" and 'Pocket' = "1")

th_R2_revPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and

```

```

('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

th_R3_PosResSen
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1")

th_R4_revPP_Cr_Th
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('Caries' = "1" or 'FracturaExploration' = "1")

th_R5_Cr_Th
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('Caries' = "1" or 'FracturaExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ReboundPain' = "1")

th_R6_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('Caries' = "1" or 'FracturaExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ReboundPain' = "1")

th_R7_revPPP

```

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
(Caries = "1" or 'Cavity' = "1")

th_R8_PTrevPP/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
('FractureClinic' = "1")

th_R9_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and

('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('EncroachXray' = "1" or 'PDLXray' = "1" or
'RadiolucentXray' = "1") and
('ReboundPain' = "1")

th_R10_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1" or 'Cavity' = "1") and
not('FractureClinic' = "1") and
not('EncroachXray' = "1" or 'PDLXray' = "1" or 'RadiolucentXray'
= "1") and
not('ReboundPain' = "1")

th_R11_refPain
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1" or
'RadiopaqueXray' = "1")

th_R12_intOssPath

```

```

('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and ('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

th_R13_revPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1" ) and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

th_R14_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1" ) and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
('ReboundPain' = "1")

th_R15_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain" ) and
('Dento_alveolar' = "1" ) and
('sharp' = "1" ) and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" ) and
not('bitingCAF' = "1" or 'chewingCAF' = "1" ) and
('TenderPercussion' = "1" ) and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries'
= "1" ) and
not('PDLXray' = "1" or 'RadiolucentXray' = "1" ) and
not('ExposedPulp' = "1" ) and
not('ReboundPain' = "1" )

th_R16_PTrevPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1" ) and
('sharp' = "1" ) and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1" and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1")

th_R17_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or

```

```

('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ReboundPain' = "1")

th_R18_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ReboundPain' = "1")

th_R19_revPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

th_R20_PosResSen
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1")

th_R21_revPP_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('Caries' = "1" or 'FractureExploration' = "1")

th_R22_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or

```

```

'OtherComplaint2' = "pain") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('EncroachXray' = "1" or 'PDLxray' = "1" or
'RadiolucentXray' = "1") and
('ReboundPain' = "1")

th_R23_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('EncroachXray' = "1" or 'PDLXray' = "1" or
'RadiolucentXray'
= "1") and
not('ReboundPain' = "1")

th_R24_revPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
('Caries' = "1")

th_R25_DenSen
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1") and
('Cavity' = "1" or 'GingivalRecession' = "1") and
('BriefSen' = "1")

th_R26_revPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1") and
('Cavity' = "1" or 'GingivalRecession' = "1") and
not('BriefSen' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1")

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th_R27_A0_refPain
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Caries' = "1") and
not('Cavity' = "1" or 'GingivalRecession' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1")

th_R28_PosResSen
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1") and
not('Encroach,Xray' = "1" or 'PDLXray' = "1" or
'RadiolucentXray' = "1")

th_R29_revPP_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
(Caries = "1" or 'FractureExploration' = "1")

th_R30_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1") and
('ReboundPain' = "1")

th_R31_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1") and
not('ReboundPain' = "1")

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th_R32_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drink.CAF' = "1") and
(bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or 'Filling' "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('EPTnegative' = "1")

th_R33_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2` = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
(bitingCAF' = "1" or 'chewingCAF' = "1") and
('Restoration' = "1" or `Filling' = "1") and
not('RecentRestoration' = "1") and
not('Caries' = "1" or 'FractureExploration' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

th_R34_AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2` = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
(bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
('Hyperocclusion' = "1")

th_R35_CrTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2` = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1" and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
(bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Hyperocclusion' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1") and
('ReboundPain' = "1")

th_R36_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
OtherComplaint2' = "Pain") and
'Dento-alveolar' = "1" and
('sharp' = "1" and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1") or 'Filling' = "1" and
not('Hyperocclusion' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1") and
not('ReboundPain' = "1")

th_R37_Pnec/AAP

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('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2` = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Hyperocclusion' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('EPTnegative' = "1")

th_R38_Pnec/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2` = "pain") and
('Dento_alveolar' = "1") and
('sharp' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
not('Hyperocclusion' = "1") and
(PDLXray' = "1" or 'Radiolucent.Xray' = "1")

th_R39_irrPP/Perio
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2` = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Mobility' = "1" and 'Pocket' = "1")

th_R40_irrPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2` = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

th_R41_CrTh/irrPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2` = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
('ReboundPain' = "1")

th_R42_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2` = "pain") and

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('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
not('ReboundPain' = "1")

th_R43_irrPP/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries'
= "1") and
(PDLXray' = "1" or 'RadiolucentXray' = "1")

th_R44_PTirrPP/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
('FractureClinic' = "1")

th_R45_CrTh/irrPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ReboundPain' = "1")

th_R46_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or

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'Caries' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ReboundPain' = "1")

th_R47_PtirrPP/AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('FractureClinic' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

th_R48_refPain_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1" or
'RadiopaqueXray' = "1")

th_R49_intOssPath
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('RadiolucentXray' = "1" or 'RadiopaqueXray' = "1")

th_R50_irrPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ExposedPulp' = "1")

th_R51_CrTh/irrPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and

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not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
('ReboundPain' = "1")

th_R52_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ExposedPulp' = "1") and
not('ReboundPain' = "1")

th_R53_irrPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

th_R54_PTirrPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
('FractureClinic' = "1")

th_R55_CrTh/irrPP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1"
or 'Caries' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('ReboundPain' = "1")

th_R56_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and

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('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('FractureClinic' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('ReboundPain' = "1")

th_R57_PtirrPP/AP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
not('bitingCAF' = "1" or 'chewingCAF' = "1") and
('TenderPercussion' = "1") and
not('Restoration' = "1" or 'Filling' = "1" or 'Cavity' = "1" or
'Caries' = "1") and
not('FractureClinic' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

th_R58_Perio
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
('Mobility' = "1" and 'Pocket' = "1")

th_R59_AAP
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
('RecentRestoration' = "1")

th_R60_Pnec/AAP_FxEndoTh
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
not('RecentRestoration' = "1") and
('FractureExploration' = "1" or 'Caries' = "1")

th_R61_AO
('MainComplaint' = "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and

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not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' = "1" or 'Filling' = "1") and
    not('RecentRestoration' = "1") and
not('FractureExploration' = "1" or 'Caries' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
not('EPTnegative' = "1")

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th_R62_Pnec/AAP

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('MainComplaint' "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' "1" or 'Filling' = "1") and
    not('RecentRestoration' = "1") and
not('FractureExploration' = "1" or 'Caries' = "1") and
not('PDLXray' = "1" or 'RadiolucentXray' = "1") and
('EPTnegative' = "1")

```

th_R63_Pnec/AAP

```

('MainComplaint' "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and

not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
('Restoration' "1" or 'Filling' = "1") and
    not('RecentRestoration' = "1") and
not('FractureExploration' = "1" or 'Caries' = "1") and
('PDLXray' = "1" or 'RadiolucentXray' = "1")

```

th_R64_Pnec/AAP

```

('MainComplaint' "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
'dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1") or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and
('Cavity' = "1" or 'Caries' = "1") and
('ExposedPulp' = "1") and
('EPTnegative' = "1")

```

th_R65_PTnec/AAP

```

('MainComplaint' "pain" or 'OtherComplaint1' = "pain" or
'OtherComplaint2' = "pain") and
('Dento_alveolar' = "1") and
not('sharp' = "1") and
('dullache' = "1" or 'throbbing' = "1") and
not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
('bitingCAF' = "1" or 'chewingCAF' = "1") and
not('Mobility' = "1" and 'Pocket' = "1") and
not('Restoration' = "1" or 'Filling' = "1") and

```



```

    not('Cavity' = "1" or 'Caries' = "1") and
    ('FractureClinic' = "1")

th_R66_Pericoro
    ('MainComplaint' "pain" or 'OtherComplaint1' = "pain" or
    'OtherComplaint2' = "pain") and
    ('Dento_alveolar' = "1") and
    not('sharp' = "1") and
    'dullache' "I" or 'throbbing' = "1") and
    not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
    ('bitingCAF' = "1" or 'chewingCAF' = "1") and
    not('Mobility' = "1" and 'Pocket' = "1") and
    not('Restoration' = "1" or 'Filling' = "1") and
    not('Cavity' = "1" or 'Caries' = "1") and
    not('FractureClinic' = "1") and
    ('PERupt' = "1")

th_R67_A0_AFP
    ('MainComplaint' "pain" or 'OtherComplaint1' = "pain" or
    'OtherComplaint2' = "pain") and
    ('Dento_alveolar' = "1") and
    not('sharp' = "1") and
    ('dullache' "I" or 'throbbing' = "1") and
    not ('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
    ('bitingCAF' = "1" or 'chewingCAF' = "1") and
    not('Mobility' = "1" and 'Pocket' = "1") and
    not('Restoration' = "1" or 'Filling' = "1") and
    not('Cavity' = "1" or 'Caries' = "1") and
    not('FractureClinic' = "1") and
    not('PERupt' "1") and
    not('PDLXray' = "1" or 'RadiolucentXray' = "1" or
    'RadiopaqueXray' = "1")

th_R67_intOssPath
    ('MainComplaint' "pain" or 'OtherComplaint1' = "pain" or
    'OtherComplaint2' = "pain") and
    ('Dento_alveolar' = "1") and
    not('sharp' = "1") and
    ('dullache' = "1" or 'throbbing' = "1") and
    not('hotfood/drinkCAF' = "1" or 'coldfood/drinkCAF' = "1") and
    ('bitingCAF' = "1" or 'chewingCAF' = "1") and
    not('Mobility' = "1" and 'Pocket' = "1") and
    not('Restoration' "1" or 'Filling' = "1") and
    not('Cavity' = "1" or 'Caries' = "1") and
    not('FractureClinic' = "1") and
    not('PERupt' = "1") and
    ('RadiolucentXray' = "1") or 'RadiopaqueXray' = "1")

```

There are many rules for the same diagnosis, therefore, the diagnosis of a particular pain can be derived from several rules. The following paragraph is summary of those rules.

th_revPP is true if any of these conditions is (are) true.

```

    'th_R2_revPP' = "T" or
    'th_R7_revPP' = "T" or
    'th_R19_revPP' = "T" or
    'th_R24_revPP' = "T" or
    'th_R26_revPP' = "T"

```

th_PosResSen

```

    'th_R3_PosResSen' = "T" or

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```

'th_R20_PosResSen' = "T" or
'th_R28_PosResSen' = "T"

th_revPP_CrTh
'th_R4_revPP_CrTh' = "T" or
'th_R21_revPP_CrTh' = "T" or
'th_R29_revPP_CrTh' = "T"

th_CrTh
'th_R5_CrTh' = "T" or
'th_R9_CrTh' = "T" or
'th_R14_CrTh' = "T" or
'th_R17_CrTh' = "T" or
'th_R22_CrTh' = "T" or
'th_R30_CrTh' = "T" or
'th_R35_CrTh' = "T"

th_AO
'th_R6_AO' = "T" or
'th_R10_AO' = "T" or
'th_R15_AO' = "T" or
'th_R18_AO' = "T" or
'th_R23_AO' = "T" or
'th_R31_AO' = "T" or
'th_R36_AO' = "T" or
'th_R42_AO' = "T" or
'th_R46_AO' = "T" or
'th_R52_AO' = "T" or
'th_R56_AO' = "T" or
'th_R61_AO' = "T"

th_PTrevPP/AAP
'th_R8_PtrevPP/AAP' = "T"

th_refPain
'th_R11_refPain' = "T"

th_intOssPath
'th_R12_intOssPath' = "T" or
'th_R49_intOssPath' = "T" or
'th_R68_intOssPath' = "T"

th_revPP/AP
'th_R13_revPP/AP' = "T"

th_PTrevPP/AP
'th_R16_PTrevPP/AP' = "T"

th_DenSen
'th_R25_DenSen' = "T"

th_AO_refPain
'th_R27_refPain_AO' = "T" or
'th_R48_refPain_AO' = "T"

th_PNec/AAP
'th_R32_Pnec/AAP' = "T" or
'th_R33_Pnec/AAP' = "T" or
'th_R37_Pnec/AAP' = "T" or
'th_R38_Pnec/AAP' = "T" or
'th_R62_Pnec/AAP' = "T" or
'th_R63_Pnec/AAP' = "T" or
'th_R64_Pnec/AAP' = "T" or

```

```

th_PTnec/AAP
    'th_R65_PTnec/AAP' = "T"

th_AAP
    'th_R34_AAP' = "T" or
    'th_R59_AAP' = "T"

th_EndoPerio
    'th_R1_revPP/Perio' = "T" or
    'th_R39_EndoPerio' = "T"

th_irrPP/AAP
    'th_R40_irrPP/AAP' = "T" or
    'th_R43_irrPP/AAP' = "T"

th_PTirrPP/AAP
    'th_R44_PTirrPP/AAP' = "T" or
    'th_R47_PTirrPP/AAP' = "T"

th_CrTh/irrPP
    'th_R41_CrTh/irrPP' = "T" or
    'th_R45_CrTh/irrPP' = "T" or
    'th_R51_CrTh/irrPP' = "T" or
    'th_R55_CrTh/irrPP' = "T"

th_irrPP/AP
    'th_R50_irrPP/AP' = "T" or
    'th_R53_irrPP/AP' = "T"

th_PTirrPP/AP
    'th_R54_PTirrPP/AP' = "T" or
    'th_R57_PTirrPP/AP' = "T"

th_Perio
    'th_R58_Perio' = "T"

th_PNec/AAP_FxEndoTh
    'th_R60_PNec/AAP_FxEndoTh' = "T"

th_Pericoro
    'th_R66_Pericoro' = "T"

th_AO_AFP
    'th_R67_AO_AFP' = "T"

```

D.7. Diagnostic Rules for Pain in the Oral Mucosa Region

```

om_R1_Ane_AcCandi
    ('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
    or 'OtherComplaint1' = "disturbance of oral sensation (eg.
    Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
    (eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1`
    = "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
    "taste change" or 'OtherComplaint1` = "taste change") and
    ('oral_mucosa' = "1") and
    ('burning` = "1" or 'tingling` = "1") and
    ('foodRF' = "1") and
    ('B12_correction' = "2" or not('serum iron' = "0" or 'serum
    iron' = "1") or not('folate' = "0" or 'folate' = "1"))

om_R2_OD

```

```

('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
('burning' = "1" or 'tingling' = "1") and
('foodRF' = "1") and
not('B12_correction' = "1") and
('serum iron' = "0" or 'serum iron' = "1") and
('folate' = "0" or 'folate' = "1")

om_R3_Ane_AcCandi
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
('burning' = "1" or 'tingling' = "1") and
not('foodRF' = "1") and
not('AtrophyMuE' = "1" or 'ErythemaMuE' = "1" or 'ErosionMuE' =
"1") and (not('serum iron' = "1" or 'serum iron' = "1" or
not('folate' = "0" or 'folate' = "1") or 'B12_correction' = "2")

om_R4_OD
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
('burning' = "1" or 'tingling' = "1") and
not('foodRF' = "1") and
not('AtrophyMuE' = "1" or 'ErythemaMuE' = "1" or 'ErosiorMuE'
"1") and
('serum iron' = "0" or 'serum iron' = "1") and
('folate' = "0" or 'folate' = "1") and
not('B12_correction' = "2")

om_R5_Ane_AcCandi
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
('burning' = "1" or 'tingling' = "1") and
not('foodRF' = "1") and
('AtrophyMuE' = "1" or 'ErythemaMuE' = "1" or 'ErosionMuE' = "1")
and
(not('serum iron' = "0" or 'serum iron' = "1" or not('folate' =
"0" or 'folate' = "1") or 'B12_correction' = "2")

om_R6_MuLe_or_Dys
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'

```

```
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
('burning` = "1" or 'tingling` = "1") and
not('foodRF' = "1") and
('AtrophyMuE' = "1" or 'ErythemaMuE' = "1" or 'ErosionMuE' =
"1") and
('serum iron` = "0" or 'serum iron' = "1") and
('folate' = "0" or 'folate' = "1") and
not('B12_correction' = "2')
```

om_R7_Apth_or_MuLe

```
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
not('burning` = "1" or 'tingling` = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
('chewingCAF' = "1") and
('ErosionMuE' = "1" or 'UlcerMuE' = "1")
```

om_R8_AFP

```
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
not('burning` = "1" or 'tingling` = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
('chewingCAF` = "1") and
not('ErosionMuE' = "1" or 'UlcerMuE' = "1" or 'ErythemaMuE' =
"1") and ('numbness' = "1" or 'numbnessASS' = "1" or 'tingling'
= "1") and ('norm_CN_finding' = "1")
```

om_R9_SecNeug

```
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
not('burning` = "1" or 'tingling` = "1") and
('sharp' = "1") or 'electric_liked' = "1") and
('chewingCAF' = "1") and
not('ErosionMuE' = "1" or 'UlcerMuE' = "1" or 'ErythemaMuE' =
"1") and ('numbness' = "1" or 'numbnessASS' = "1" or 'tingling'
= "1") and
not('norm_CN_finding' = "1")
```

om_R10_TN_GN

```
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
not('burning` = "1" or 'tingling` = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
```

```

('chewingCAF' = "1") and
not('ErosionMuE' = "1" or 'UlcerMuE' = "1" or 'ErythemaMuE' =
"1") and
not('numbness' = "1" or 'numbnessASS' = "1" or 'tingling' =
"1")

om_R11_AFP
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
not('burning' = "1" or 'tingling' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('chewingCAF' = "1") and
('numbness' = "1" or 'numbnessASS' = "1" or 'tingling' = "1")
and
('norm_CN_finding' = "1")

om_R12_SecNeug
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
not('burning' = "1" or 'tingling' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('chewingCAF' = "1") and
('numbness' = "1" or 'numbnessASS' = "1" or 'tingling' = "1")
and
not('normal_CN_finding' = "1")

om_R13_TN_GN
('MainComplaint' = "disturbance of oral sensation (eg. Burning)"
or 'OtherComplaint1' = "disturbance of oral sensation (eg.
Burning)" or 'OtherComplaint2' = "disturbance of oral sensation
(eg. Burning)" or 'MainComplaint' = "pain" or 'OtherComplaint1'
= "pain" or 'OtherComplaint2' = "pain" or 'MainComplaint' =
"taste change" or 'OtherComplaint1' = "taste change") and
('oral_mucosa' = "1") and
not('burning' = "1" or 'tingling' = "1") and
('sharp' = "1" or 'electric_liked' = "1") and
not('chewingCAF' = "1") and
not('numbness' = "1" or 'numbnessASS' = "1" or 'tingling' =
"1")

```

There are many rules for the same diagnosis, therefore, the diagnosis of a particular pain can be derived from several rules. The following paragraph is summary of those rules.

```

om_OD
'om_R2_OD' = "T" or
'om_R4_OD' = "T"

om_Ane_AcCandi
'om_R1_Ane_AcCandi' = "T" or
'om_R3_Ane_AcCandi' = "T" or

```

```
'om_R5_Ane_AcCandi' = "T"

om_SecNeug
  'om_R9_SecNeug' = "T" or
  'om_R12_SecNeug' = "T"

om_TN_GN
  'om_R10_TN_GN' = "T" or
  'om_R13_TN_GN' = "T"

om_AFP
  'om_R8_AFP' = "T" or
  'om_R11_AFP' = "T"

om_Apth_MuLe
  'om_R7_Apth_or_MuLe' = "T"

om_MuLe_Dysp
  'om_R6_MuLe_or_Dysp' = "T"
```